VEHICLE ENGINEERING

	Presenter:
	Organization/Date: Orbiter/06-28-01

ORBITER	To Be Presented
SOFTWARE	No Constraints
FCE	No Constraints
GFE	To Be Presented
FLIGHT READINESS STATEMENT	To Be Presented
BACKUP	

Orbiter

AGENDA

Presenter: Mike Burghardt

Organization/Date: Orbiter/06-28-01

Engineering Readiness Assessment

• Previous Flight Anomalies	To Be Presented
• Critical Process Changes	To Be Presented
• Engineering Requirement Changes	No Constraints
• Configuration Changes	To Be Presented
• Mission Kits	No Constraints

Special Topics — To Be Presented

- MPS Feedline Support Fasteners
- TPS Drying/Waterproofing
- OMS Pod Vibration
- Radiator Isolation Valve Circuit Breakers
- MPS/PRSD Cryo Skid Test Stand
- Aft LCA Power Connector Lugs

	Presenter:
	Organization/Date: Orbiter/06-28-01

PREVIOUS FLIGHT ANOMALIES

	Presenter:
	Organization/Date: Orbiter/06-28-01

STS-100
IN-FLIGHT ANOMALIES

PREVIOUS IN-FLIGHT ANOMALIES

Presenter: Mike Burghardt

Organization/Date: Orbiter/06-28-01

STS-100 In-Flight Anomalies, Previous Mission:

- Three problems identified
  - STS-100-V-01: FES Starboard Feedline Zone 3 Heater System 1 Failed Off
  - STS-100-V-03: WSB 3 Anomalous Temperature Response on Controller B
  - STS-100-V-04: Vernier Thruster R5D Low Chamber Pressure
  - Details presented on following pages

All anomalies and funnies have been reviewed and none constrain STS-104 flight

STS-100-V-01: FES H_2O FEEDLINE B HEATER STRING 1 FAILED	Presenter: Mike Burghardt Organization/Date: Orbiter/06-28-01

Observation:

- FES B (stbd) supply H_2O feedline heater 1 zone 3 failed off and the line temperature (V63T1875A) dropped to about 52°F

Concern:

- Without corrective action, loss of a second heater may result in FES feedline freezing and potential loss of one of the FES systems

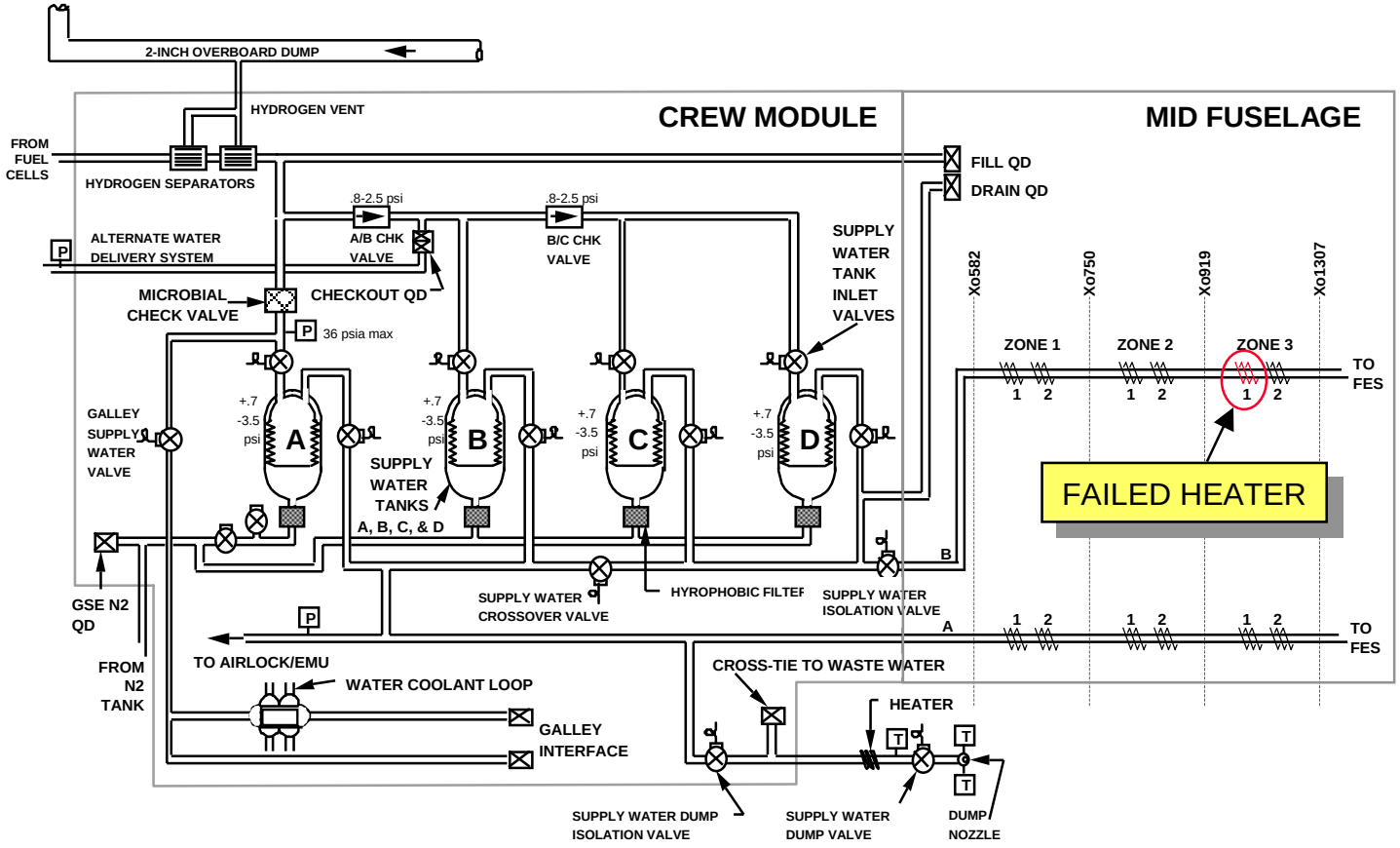
Discussion:

- Water line temperature in zone 3 drifted to around 52°F at MET 000:13:00 (vs 65F to 90F typical) indicating heater failure
  - No heater cycles seen following application of heater string 1 power post-launch
- Heater is required to prevent water line freezing in cold attitudes
- There are two heater strings per feedline

STS-100-V-01: FES H_2O FEEDLINE B HEATER STRING 1 FAILED

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

SUPPLY WATER SYSTEM



STS-100-V-01: FES H_2O FEEDLINE B HEATER STRING 1 FAILED	Presenter: Mike Burghardt Organization/Date: Orbiter/06-28-01

Discussion (Cont):

- Analysis, based on planned STS-100 docked attitude, predicted that water line temperature would reach 32°F within three hours with no heater
- Heater string 2 was enabled at MET 000:17:20 and system performed nominally
- A contingency line purging procedure was in place in the event of a second heater string failure

Actions Taken:

- Post-flight troubleshooting found a broken wire at the heater ground point

STS-100-V-01: FES H_2O FEEDLINE B HEATER STRING 1 FAILED	Presenter: Mike Burghardt Organization/Date: Orbiter/06-28-01

Acceptable for STS-104 Flight:

- FES heater string operation was verified as part of in flight checkout OMRS file IX requirements during the last OV-104 mission (STS-98)
- In the event of a heater failure, the redundant heater string may be used
- With loss of both heater strings, a contingency procedure to purge the affected line is available to prevent freezing and allow recovery of the system for entry

STS-100-V-03: WSB 3 ANOMALOUS TEMPERATURE RESPONSE ON CONTROLLER B

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Observation:

- WSB #3 temperatures for GN_2 tank, water tank and WSB core rose abnormally on controller B

Concern:

- Failure might result in loss of WSB cooling and therefore loss of one APU

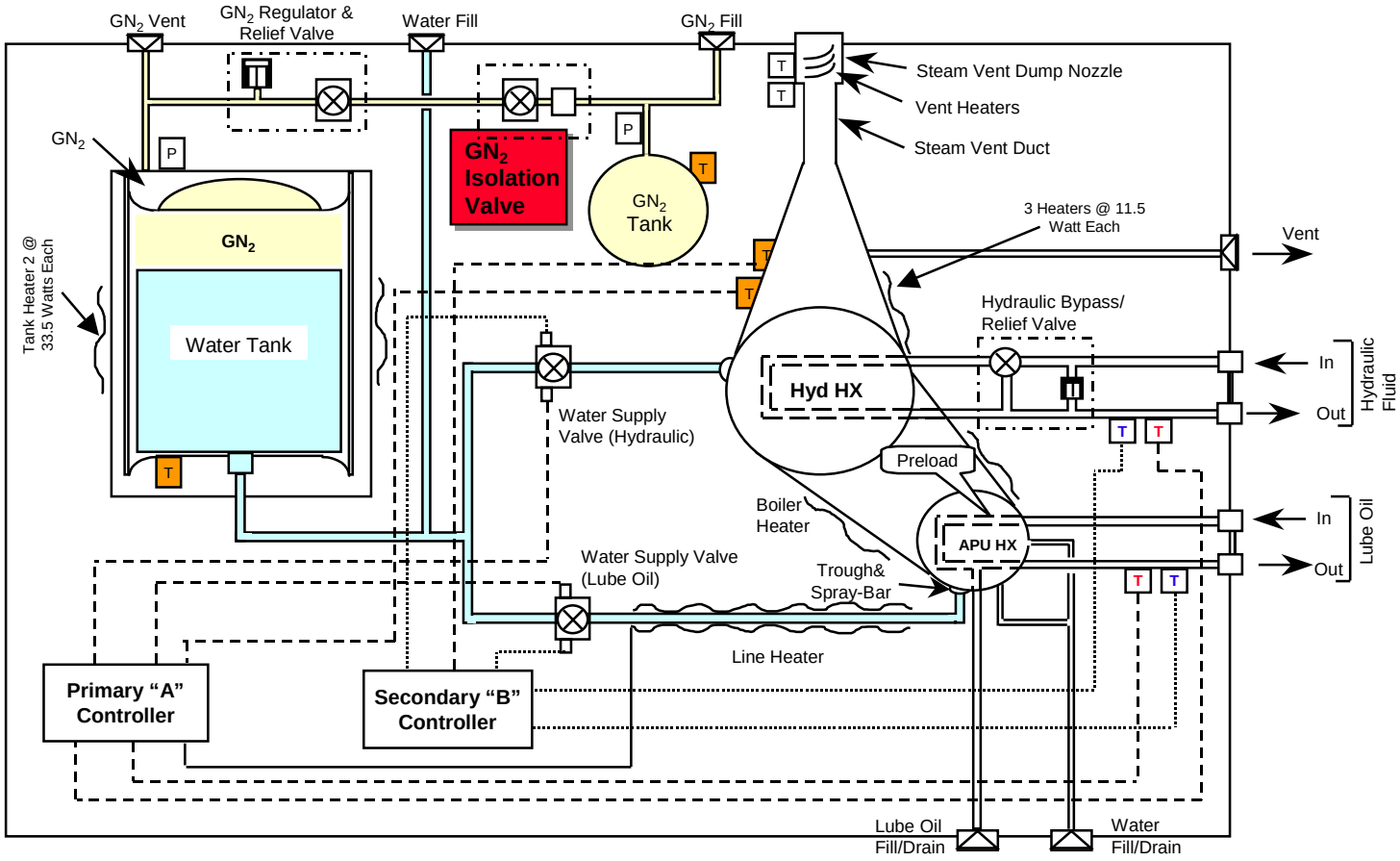
Discussion:

- WSB 3 was switched, as planned, from controller A to controller B approximately 24 hours after launch
  - Three WSB 3 temperature measurements rose unexpectedly over the next three days
    - GN_2 tank temp increased from 78°F to 83°F
    - Core temp increased from 72°F to 77°F
    - Water tank temp increased from 75°F to 78°F
- WSB 3 was switched back to A controller after 77 hrs on the B controller
  - Temperatures recovered to normal

STS-100-V-03: WSB 3 ANOMALOUS TEMPERATURE RESPONSE ON CONTROLLER B

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

WATER SPRAY BOILER SYSTEM SCHEMATIC



STS-100-V-03: WSB 3 ANOMALOUS TEMPERATURE RESPONSE ON CONTROLLER B	Presenter: Mike Burghardt Organization/Date: Orbiter/06-28-01

Actions Taken:

- Post-flight troubleshooting has isolated the source of the heat to the GN_2 isolation valve
  - A failure within the controller caused the isolation valve to remain powered and act as a heater, supplying 37.5 watts of energy
    - Multiple single point failures within the controller can produce this failure; none are common to both A and B controller
- The controller has been removed and routed to NSLD for TT&E
  - The failure has been isolated to circuit board #8 where the output current for the GN_2 isolation valve is always on
    - The circuit board will be replaced with a spare
    - Failure analysis will begin on the failed circuit board

STS-100-V-03: WSB 3 ANOMALOUS TEMPERATURE RESPONSE ON CONTROLLER B

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Risk Assessment:

- With continued operation on a controller producing this temperature anomaly, there are no adverse effects on WSB system
  - No issue with GN_2 tank, water tank, or WSB container over-pressurization
  - GN_2 isolation valve operation is not compromised
- Alternate controller is available

Acceptable for STS-104 Flight:

- OV-104 WSB operation was verified per OMRS test requirements
- In the event of a similar failure, the WSB will be switched to the alternate controller

STS-100-V-04: VERNIER THRUSTER R5D INTERMITTENT LOW CHAMBER PRESSURE	Presenter: Mike Burghardt Organization/Date: Orbiter/06-28-01

Observation:

- RCS vernier thruster S/N 401(R5D) had low combustion chamber pressure (Pc) indications on several pulses in preparation for undocking with ISS

Concern:

- Potential for deselection of R5D vernier thruster

Discussion:

- Vernier thruster R5D chamber pressure was intermittently low prior to undock through final use prior to entry
  - Pc varied from low of 50 psia to nominal ~108 psia
- RM did not deselect R5D
  - Vernier thruster deselects when Pc is < 26 psia in presence of an RPC fire command for three samples

STS-100-V-04: VERNIER THRUSTER R5D INTERMITTENT LOW CHAMBER PRESSURE	Presenter: Mike Burghardt Organization/Date: Orbiter/06-28-01

Discussion (Cont):

- Injector temperatures were nominal
- Prior to occurrence, R5D had been used for two reboost sessions with nominal Pc
- Unable to verify from flight data whether low Pc indications were accurate representations of actual chamber pressure
  - Indications may be instrumentation only
- ALT DAP used during crew sleep to avoid alarm if thruster failed
- Possible causes of low Pc:
  - Restriction in oxidizer or fuel valve orifice
  - Combustion products (FORP) in Pc tube
- Vernier thruster Pc tubes are flushed at OMDP

STS-100-V-04: VERNIER THRUSTER R5D INTERMITTENT LOW CHAMBER PRESSURE	Presenter: Mike Burghardt Organization/Date: Orbiter/06-28-01

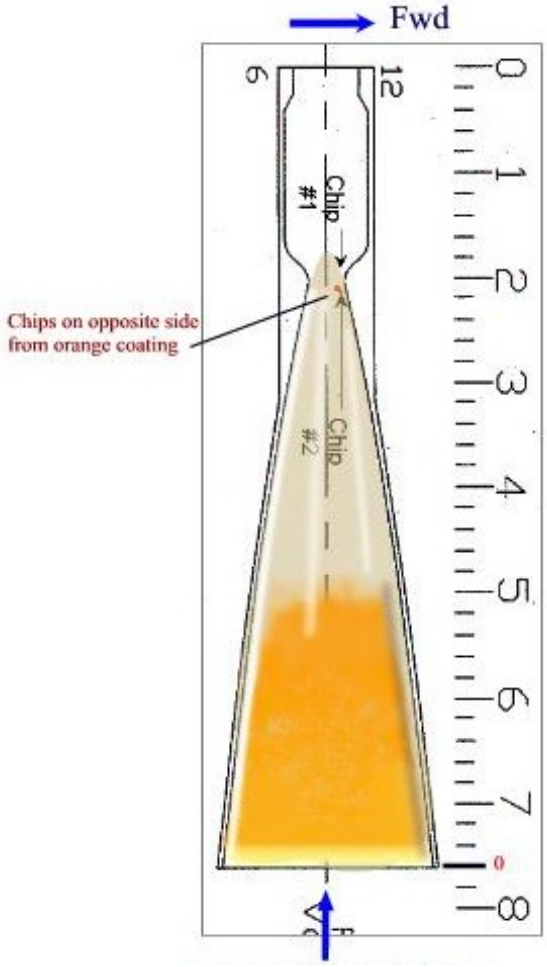
Actions Taken:

- Visual inspection found bright powdery-orange area in divergent part of nozzle
  - Unable to obtain sample (would not scrape off using teflon tool or come off using IPA/wipe)
- Borescope inspection of combustion chamber was performed
  - No sign of contamination on injector
  - No evidence of blockage at Pc port
  - Existing chip in throat (which was .04” x .04” previously) is now .08” x .09”
- The thruster was removed and there were no external abnormalities on Pc tube
- The thruster was shipped to WSTF
  - TT&E is underway, initial results expected by 7/9/01

STS-100-V-04: VERNIER THRUSTER R5D INTERMITTENT LOW CHAMBER PRESSURE

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

VERNIER THRUSTER R5D S/N 401



STS-100-V-04: VERNIER THRUSTER R5D INTERMITTENT LOW CHAMBER PRESSURE	Presenter: Mike Burghardt Organization/Date: Orbiter/06-28-01

Actions Taken (cont):

- Reviewed qual data for off-nominal vernier thruster testing
  - Significant number of low Pc firings due to low mixture ratio performed during qual and reboost tests
    - Some evidence of clogging in Pc tube seen and restriction of oxid valve trim orifice
  - No detrimental effects to thrust chamber or Pc tube

Actions Planned:

- Complete TT&E at WSTF
- For upcoming missions, a vernier thruster with the same signature will not be fired until the failure analysis is complete and the cause is understood

STS-100-V-04: VERNIER THRUSTER R5D INTERMITTENT LOW CHAMBER PRESSURE	Presenter: Mike Burghardt Organization/Date: Orbiter/06-28-01

Risk Assessment:

- Failed off vernier thruster due to blocked inlet valves/pressure transducer tube (crit 2/2)
  - Loss of single vernier thruster
  - Thruster would be deselected by RM
    - Flight rules allow primary thruster use for docking, attitude control and reboost if necessary
    - Potential effect on vernier reboost mission objective, depending on which thruster failed
      - Less efficient– propellant/timeline impacts
  - Another potential effect of a restricted fuel or oxidizer injector is an off-nominal mixture ratio
    - Data from qual and reboost testing of off-nominal mixture ratios showed no deleterious effects on thruster
      - Some Pc tube blockage and valve flow restriction observed
    - The worst-case effect is RM deselection of the thruster

STS-100-V-04: VERNIER THRUSTER R5D INTERMITTENT LOW CHAMBER PRESSURE	Presenter: Mike Burghardt Organization/Date: Orbiter/06-28-01

Acceptable for STS-104 Flight:

- No indication of low Pc on OV-104 vernier thrusters during last flight (STS-98)
  - Pc tubes flushed at OMDP three flights ago
- Significant qual test data indicates low Pc not detrimental to thruster
- If the same signature were to recur, the thruster would be deselected
  - Not a safety of flight issue
  - Possible effect on reboost mission objectives

	Presenter:
	Organization/Date: Orbiter/06-28-01

STS-98
IN-FLIGHT ANOMALIES

PREVIOUS IN-FLIGHT ANOMALIES

Presenter: Mike Burghardt
Organization/Date: Orbiter/06-28-01

STS-98 In-Flight Anomalies, Previous OV-104 Mission:

- Two problems identified
  - STS-98-V-01: LH_2 Engine 1 Prevalve Open Position Indicator B Failed Off
  - STS-98-V-02: Pilot and Commander HUD Misalignment

All anomalies and funnies have been reviewed and none constrain STS-104 flight

	Presenter:
	Organization/Date: Orbiter/06-28-01

CRITICAL PROCESS CHANGES

STS-104 CRITICAL PROCESS CHANGE REVIEW SUMMARY

Presenter: Mike Burghardt

Organization/Date: Orbiter/06-28-01

Item Reviewed	No. of Items Reviewed	Period or Effectivity Covered	No. Found To Be Critical Process Changes
OMRSD Changes (RCNs)	7	STS-104 Specific & Non-Flight Specific Changes Approved 3/02/01 – 5/02/01	0
OMRSD Waivers & Exceptions	9	STS-104 Specific	0
IDMRD Changes (MCNs)	13	Approved 3/02/01 – 5/02/01	1
IDMRD Waivers & Exceptions	1	Approved 3/02/01 – 5/02/01	0
EDCPs	14	Closed 3/02/01 – 5/02/01	3
Boeing Specifications	52	Released 3/02/01 – 5/02/01	4
Boeing Drawings	451	Released 3/02/01 – 5/02/01	0
Material Review	365	Approved 3/02/01 – 5/02/01	0

- All process changes were reviewed and none constrain STS-104

CRITICAL PROCESS CHANGES

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

MCN OM2991, RCS Pressure Relief Valve Updates

- This MCN updates the IDMRD to implement replacement of Freon 113 with HFE 7100 for general cleaning, final cleaning and final cleanliness verification during ATP. Requirement to verify removal of residual HFE 7100 after final cleaning and bake out has also been added.
- MCN implements Freon replacement as previously approved on OCR for OMS/RCS components.

CRITICAL PROCESS CHANGES

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

EDCP 1414-507 EDCP0024, Two-Inch Disconnect Casting Material Change

- This EDCP changes the casting material for the MPS 2-inch disconnect body, cap, and poppet from CRES investment casting material per AMS5360 to CF-8M alloy per ASTM A74. Subtier vendor's inability to consistently meet minimum mechanical properties specified on the drawings is the driver for this change.
- CF-8M has been proven by test to meet required mechanical properties. Changes will affect all future procurement of ET production and Orbiter spare hardware. Boeing procurement specification and drawings will be updated to reflect new dash number; parts will be interchangeable with current material parts.

CRITICAL PROCESS CHANGES

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

EDCP OSC S109-0021, Air Half Coupling (1/4”) Specification Substitutions

- Updates OSC drawing to replace outdated MIL specifications for TIG welding and dye penetrant processes with AMS and ASTME industry equivalent standards to comply with DCAS requirement on use of current process specifications.
- M&P engineering has evaluated the components to be welded/dye penetrated and found no issues with the specification substitutions. The form, fit, and function of the coupling will not be affected by implementation of the change.

CRITICAL PROCESS CHANGES

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

EDCP 57334a, MLG Inner Wheel Bearing Grease Seal Fabrication Process Change

- This EDCP authorizes the use of transfer molding process (gravity-fed injection type) in place of rubber compression molding process. New process will create a seal with small sprue marks on non-critical surfaces of the seal. No material change or material property change results from this EDCP.
- First article sectioning and hardness testing verified new process meets requirement. Process controls at subtier vendor are in place. No changes to fit or function as result of this process change.

CRITICAL PROCESS CHANGES

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Boeing Specifications:

MA0104-301 AH03, Applied Markings

- This process specification updates ink and catalyst in-process mixture ratios to reflect vendor recommendations
- M&P Engineering has verified that end product material (ink) is unchanged

MA0106-338 Rev E, Application of Liquid Shim

- This process specification was updated increase allowable liquid shim thickness
- Test program was conducted to verify properties of epoxy material shim meet requirements at increased thickness

CRITICAL PROCESS CHANGES

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Boeing Specifications (cont):

MA0106-340 Rev F, Bonding with Neoprene Base Adhesive

- This process specification was updated to allow heat assisted cure
- Analysis of material properties concluded that heat assisted cure would result in acceptable bond condition and achieve desired effect of decreasing total cure time

CRITICAL PROCESS CHANGES

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Boeing Specifications (cont):

MF0004-039, Rev M, Orbiter Program Contamination Control Requirements

- Specification revised to add specific hardware that has been approved for cleaning with Freon replacements. Four replacement fluids were included: AK225, AK225G, Vertrel MCA, and HFE7100
- Replacement cleaning solvents have been previously approved on a part specific basis; testing and analysis used to demonstrate compatibility
- Other changes made to reflect NASA SE-S-0073 requirements

	Presenter:
	Organization/Date: Orbiter/06-28-01

CONFIGURATION CHANGES

CONFIGURATION CHANGES AND CERTIFICATION STATUS	Presenter: Mike Burghardt Organization/Date: Orbiter/06-28-01

17 Modifications Were Incorporated During The STS-104 Processing Flow

- Five modifications are flying for the first time
  - MCR 17177 Freon Loop #2 Relief Line Reroute
  - MCR 19376 Lightweight Locker Upgrades
  - MCR 19494 Redundant Drag Chute Reefing Actuation Lanyard (Attrition)
  - MCR 23021 MEDS Cooling Vent
  - MCR 23033 ISS WCS (GFE)

- Details provided on the following pages

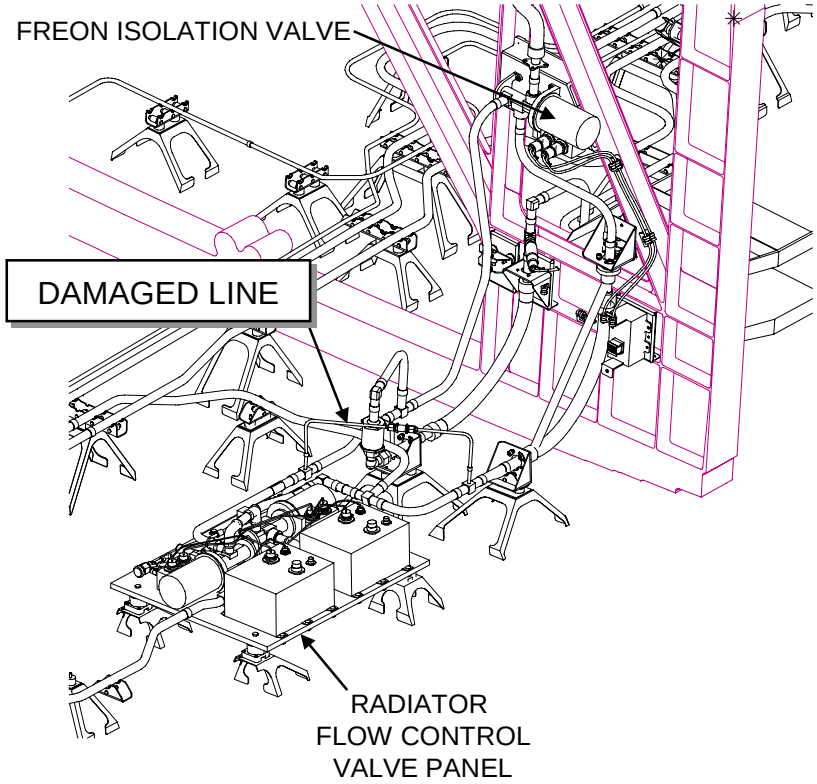
CONFIGURATION CHANGES AND CERTIFICATION STATUS

Presenter: Mike Burghardt

Organization/Date: Orbiter/06-28-01

First Flight of MCR 17177 Freon Relief Line Reroute

- Reroutes the freon loop #2 (starboard) ¼" relief line which was susceptible to damage during maintenance operations



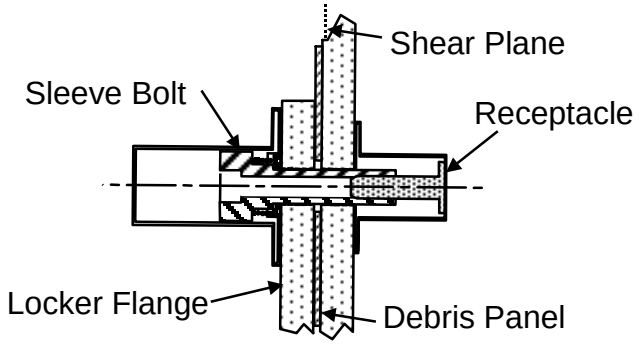
LINE REROUTED UNDER EXISTING PLUMBING

CONFIGURATION CHANGES AND CERTIFICATION STATUS

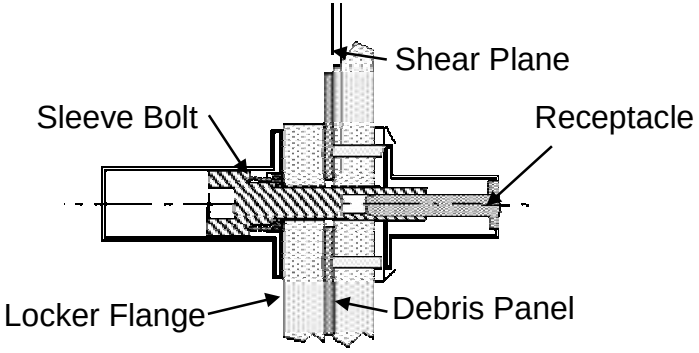
Presenter: Mike Burghardt
Organization/Date: Orbiter/06-28-01

First Flight of MCR 19376 Lightweight Locker Upgrades:

- Previous design of mid-deck locker sleeve bolts do not meet 20g crash load requirement at lower positions (OVEI waiver approved)
- The lockers, debris panels and thermal panels have been modified to ensure that the solid fastener cross-section is positioned at the locker-to-structure shear plane
  - Lockers were simultaneously modified to add double acting latches and shims for better fit of fire port extension hose
- 18 lockers as well as MA9N soft stowage bag mounting panel have been modified to the new configuration



Previous Design



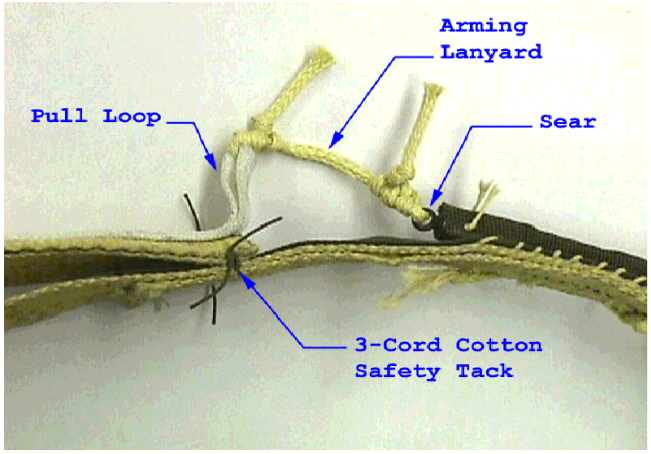
Current Design

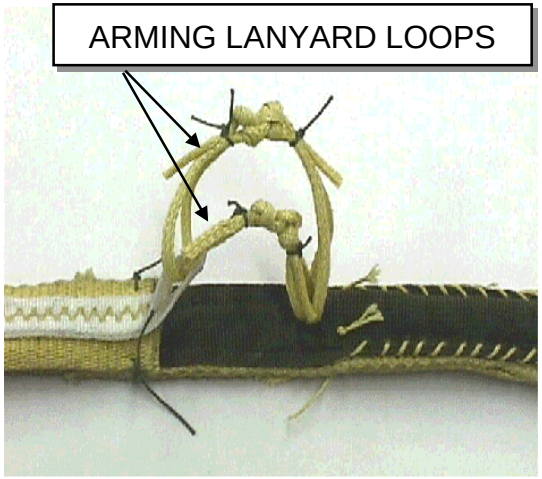
CONFIGURATION CHANGES AND CERTIFICATION STATUS

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

First Flight of MCR 19494 Drag Chute Reefing Lanyard

- Revises reefing release actuation lanyard to provide additional redundancy
  - Provides second (longer) lanyard to actuate the reefing sear (cutter) in the event the first lanyard fails
  - Corrective action from one sear not firing on STS-96 deploy





PREVIOUS CONFIGURATION - SINGLE LANYARD NEW CONFIGURATION – TWO LANYARD LOOPS

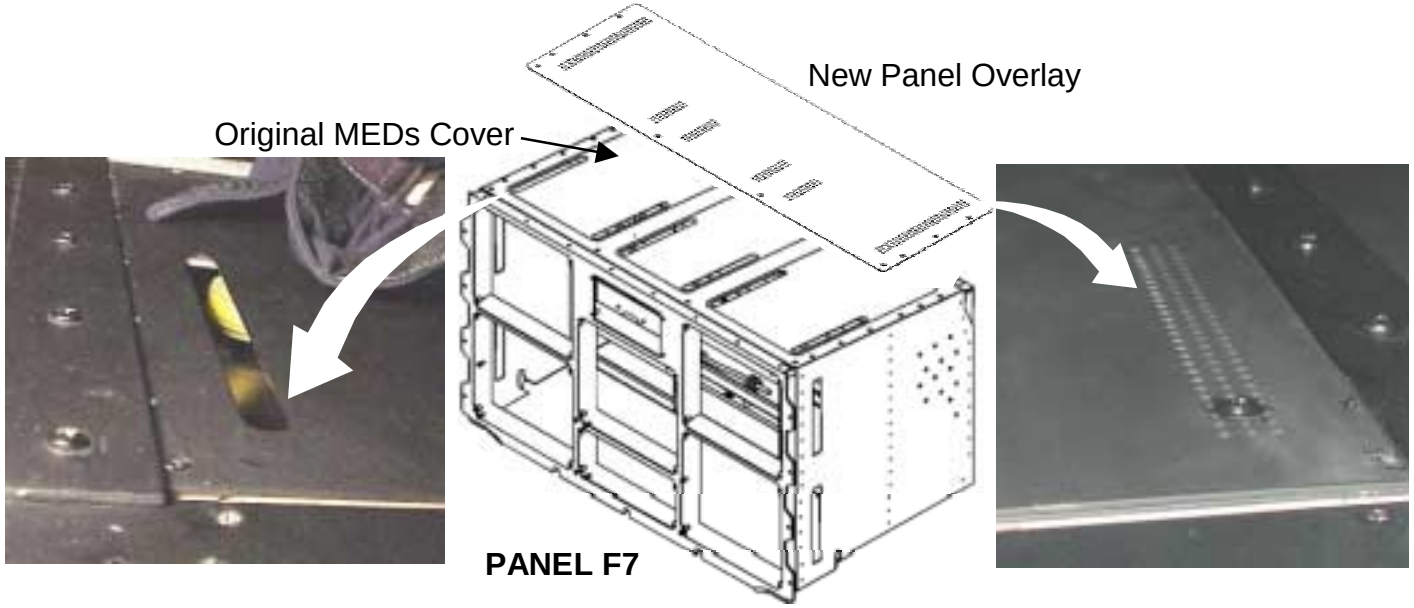
CONFIGURATION CHANGES AND CERTIFICATION STATUS

Presenter: Mike Burghardt

Organization/Date: Orbiter/06-28-01

First Flight of MCR 23021 MEDS Cooling Vent:

- Installs a new closeout overlay panel on the forward upper console which mitigates risk of damage from a lightning strike
  - Temporary 1/2 size overlay panel is installed over the existing upper F7 closeout panel
    - Eliminates requirement for an EMI waiver

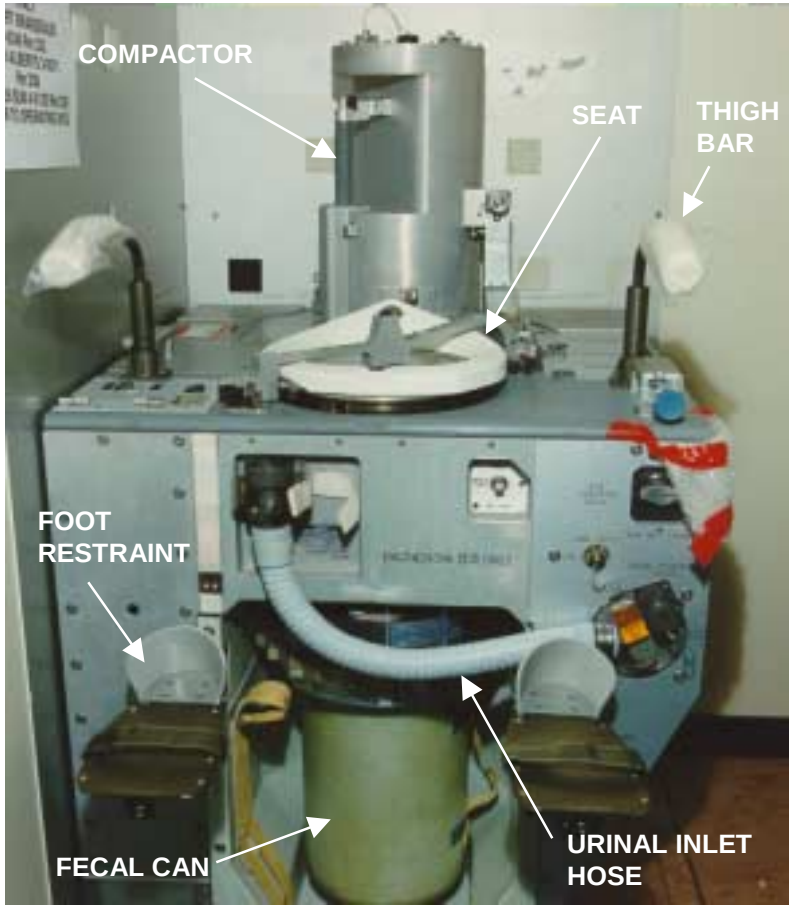


CONFIGURATION CHANGES AND CERTIFICATION STATUS

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

First Flight of MCR 23033 ISS WCS:

- Objectives:
  - Verify ISS WCS zero-g specific design modifications
    - Fan/sep design mod to prevent liquid migration
    - Commode subsystem mod to improve airflow dynamics
  - Evaluate new female urine funnel
  - Evaluate new urine pre-filters
  - Evaluate consumables redesign (fecal bag, lid, and canister)



	Presenter:
	Organization/Date: Orbiter/06-28-01

SPECIAL TOPICS

SPECIAL TOPICS FOR THE STS-104 FLIGHT READINESS REVIEW	Presenter:
	Organization/Date: Orbiter/06-28-01

Topics

MPS Feedline Support Fasteners

TPS Drying/Rewaterproofing

OMS Pod Vibration

Radiator Isolation Valve Circuit Breakers

MPS/PRSD Cryo Skid Test Stand

Aft LCA Power Connector Lugs

MPS FEEDLINE SUPPORT FASTENERS

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Observation:

- Gap noted under a fastener head and nut on OV-103 LH_2 feedline support

Concern:

- Loss of preload raises concern for loss of fasteners that could affect structural integrity

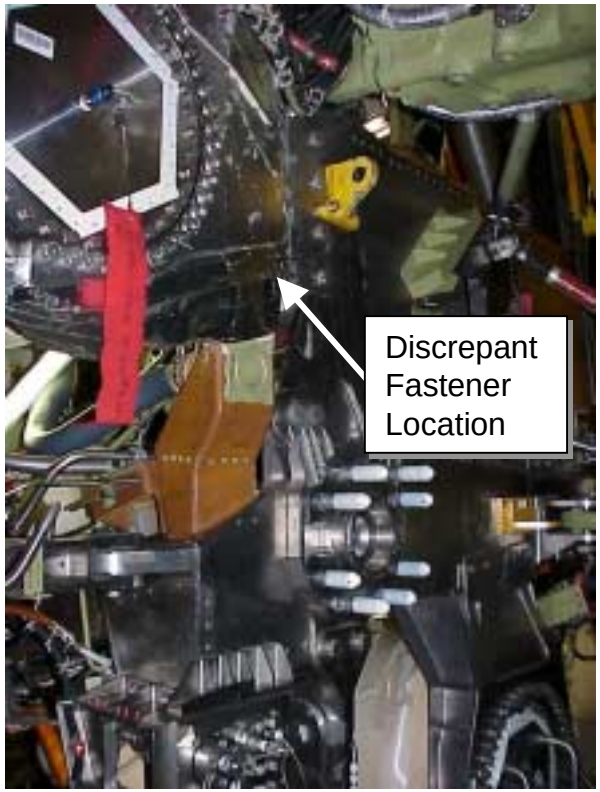
Discussion:

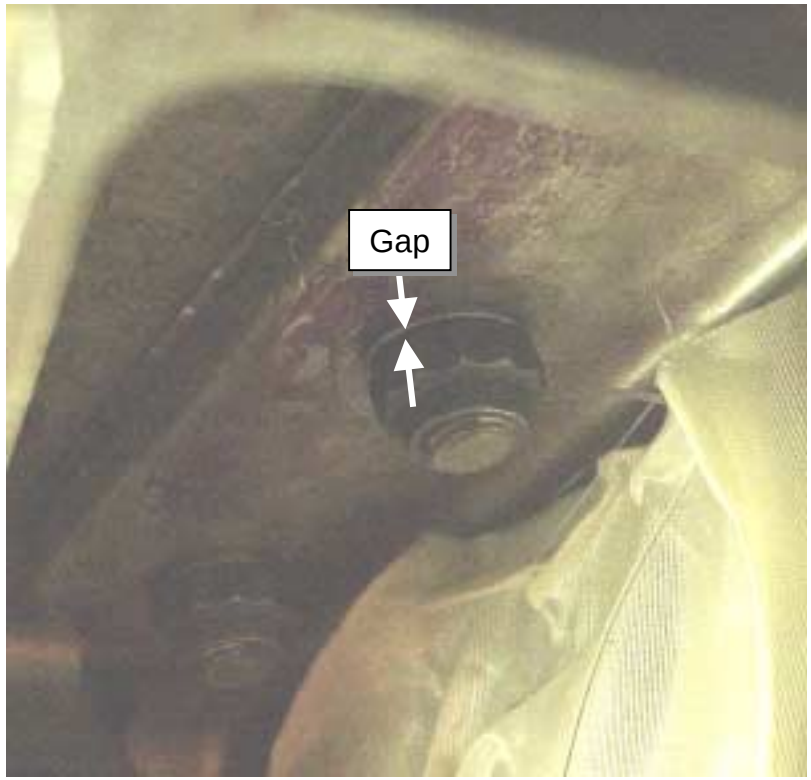
- During V30 structural inspection on OV-103 MPS LH_2 feedline support structure, a discrepant fastener was found
  - Gap under the fastener head was 0.008”
  - Gap under nut was 0.023”
  - Breakaway torque was 30 in-lbs (460-540 in-lbs required)
- Further investigation revealed fastener torque was below specification on all of fasteners on this feedline support

MPS FEEDLINE SUPPORT FASTENERS

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

OV-103 LH_2 Feedline Fasteners





MPS FEEDLINE SUPPORT FASTENERS

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Discussion:

- Stress PRT confirmed that fasteners are in pure shear
  - Loss of pre-load does not affect margin of safety
  - Provided fasteners are retained, this is not a safety concern

Actions Taken:

- All OV-104 feedline support fasteners were inspected for thread engagement and gaps and torque was checked on accessible fasteners
  - All of the bolts had proper engagement with lock nut
  - Six small gaps, 0.010” maximum, all less than 180 degrees, implying gaps caused by hole angularity
  - 38 of 81 bolts torque checked – 32 in range, 6 with reduced torque, all at least 60% of specified range

Acceptable for STS-104 Flight:

- Bolts are fully engaged into nut locking features
- No pre-load required for this application – no stress margin concern

OV-104 WET TILES

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Observation:

- OV-104 thermal protection system tiles were saturated with rain at Dryden following STS-98

Concern:

- Presence of water during on-orbit operations can lead to freezing and tile fracture

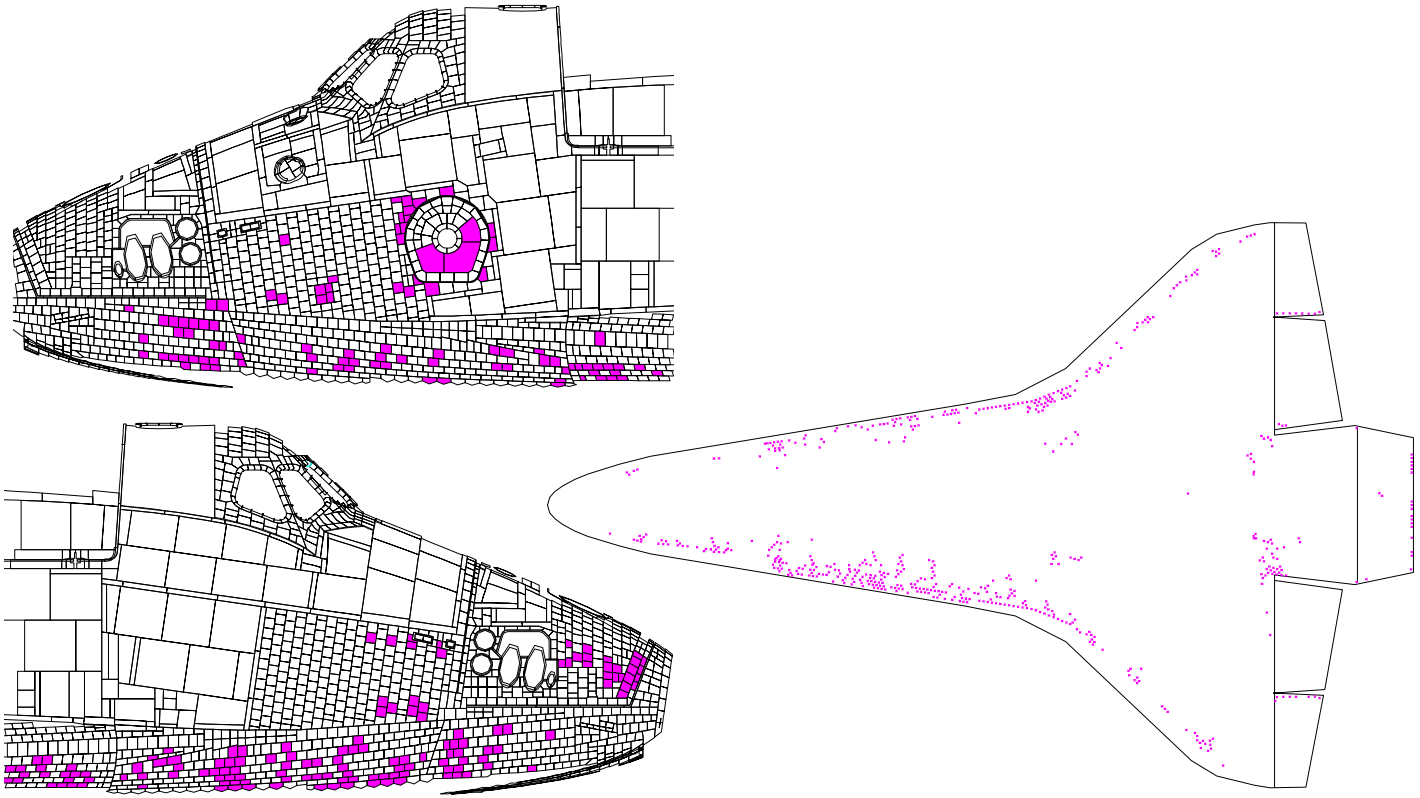
Discussion:

- OV-104 was subjected to six days of heavy rain during DFRF operations
- Thousands of tiles were wet per IR scan at OPF roll in
- On 3/13/01, IR scan showed hundreds of tiles remained wet, so active tile drying was initiated
- By 5/4/01, 146 tiles remained wet per IR scan
  - Mainly in the RH chine area, LESS carrier panels, and outboard of LH MLGD – areas concentrated at the dripline or protected from direct application of heat lamps

OV-104 WET TILES

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

799 ACTIVELY DRIED TILES



OV-104 WET TILES

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

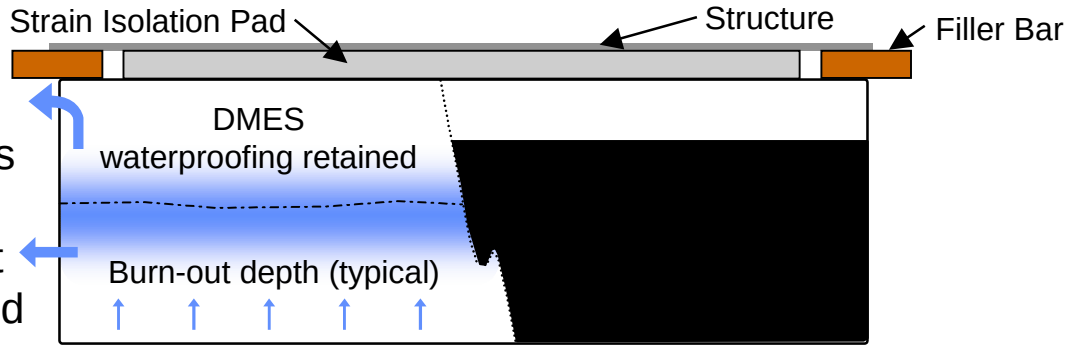
Actions Taken:

- Subsequent IR scans revealed some wet tiles which had previously been declared dry (same problem areas)
  - During baking, water migrates away from OML and concentrates at IML – after removal of heat, water re-diffuses to OML
  - False dry IR scan applies only to tiles which have been baked
- Continued to actively dry tiles which were still wet or which showed up wet again on IR scan
- Baked tile arrays with concentrations of “problem tiles”
  - All actively dried tiles were baked until there was no visible water escaping from the tile (minimum of 4 hours)
- Lab tests were performed which showed water loss rate slowed considerably after first two hours
  - 12 percent water remained in the tile after 2 hours
  - Confirmed PRT conclusion that remaining water was concentrated at tile IML immediately after heating

OV-104 WET TILES

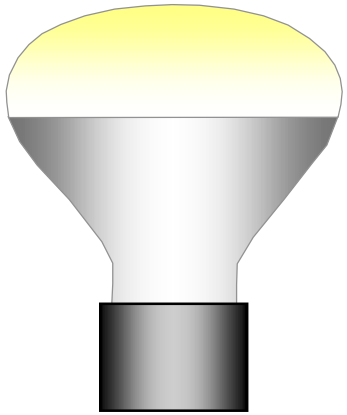
Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

TILE WATERPROOF/DRYING CHARACTERISTICS



Water escapes through tile vent area and coating cracks

With heat, water migrates away from OML

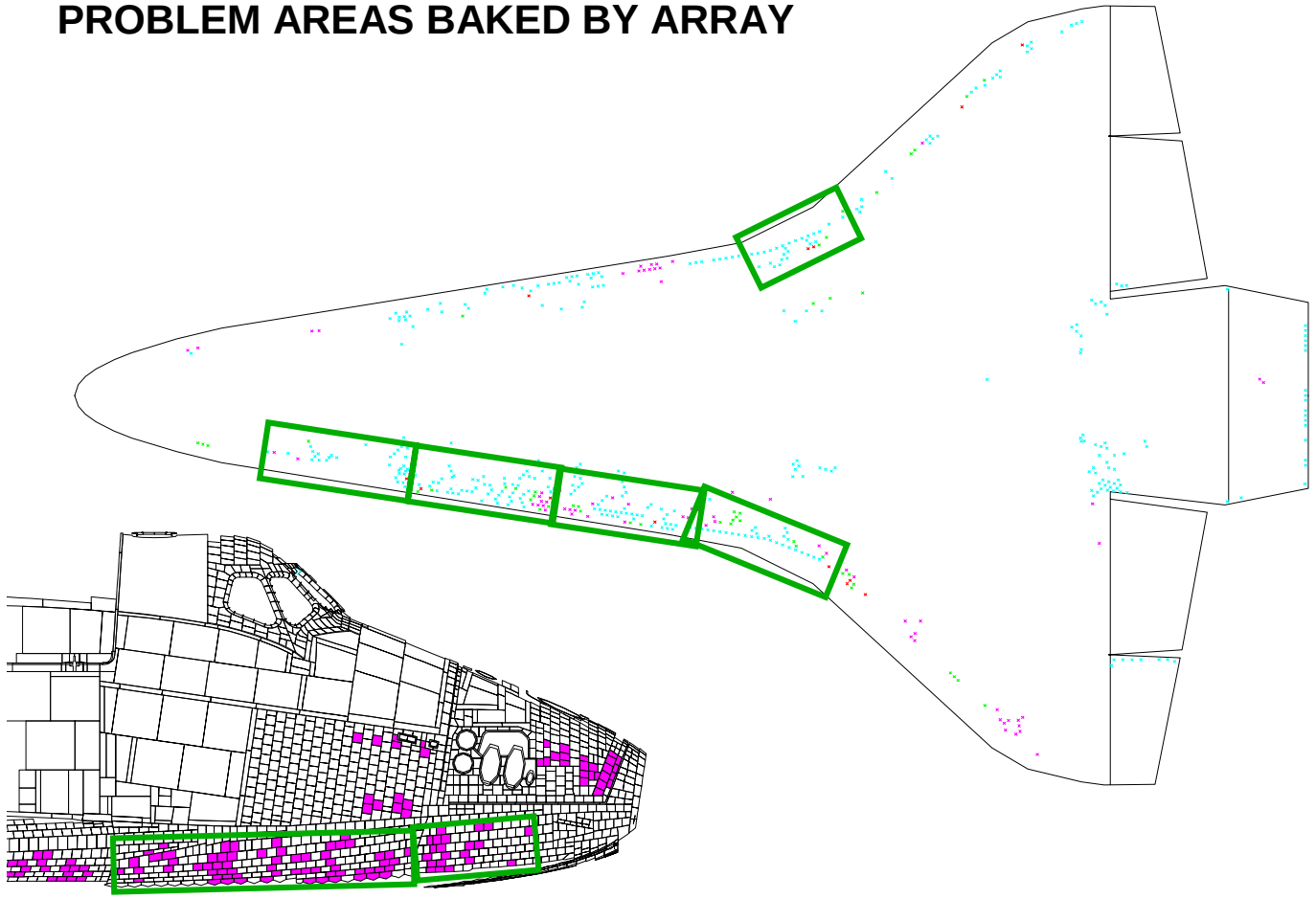


Heat lamps are placed immediately adjacent to tile to raise the surface temperature to 250-300°F

OV-104 WET TILES

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

PROBLEM AREAS BAKED BY ARRAY



OV-104 WET TILES

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Actions Taken (cont):

- 1985 NASA test program developed tile fracture threshold for temperature vs. water content
  - Showed that less than 20% water in a tile will not result in a fracture at any temperature
- PRT concluded that the baking protocol used dries the tile to well below the 20% limit from the 1985 testing
- Additional lab testing characterized tile rewaterproofing when a small amount of water remains
  - With an initial 15% water content, test tile successfully accepted waterproofing with three waterproofing applications and a total of 8cc DMES applied
    - Verified by water repel test of a dissected lab sample and supported by successful water repel test performed on five cored sections removed from OV-104 “problem” tiles
    - Application of DMES drives out additional water
- Verified all tiles which were baked received the required waterproofing protocol

OV-104 WET TILES

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Risk Assessment:

- TPS tiles are criticality 1/1
  - Risk of tile damage/loss was eliminated by drying the tile for a minimum of 4 hours or until no visible water was escaping from the tile
    - Ensures water content is below the threshold where on-orbit freezing is a concern
  - Special waterproofing protocol ensures baked tiles are fully waterproofed

Acceptable for STS-104 Flight:

- All OV-104 tiles have been dried and rewaterproofed
  - All wet tiles either dried naturally or were baked a minimum of four hours or until no visible water was escaping
  - Lab testing verified the drying time conservatively protects from potential damage due to freezing
  - Lab and on-vehicle core samples verify tile was successfully rewaterproofed

OMS POD VIBRATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Observation:

- Left OMS pod vibration observed on STS-100 launch film at SSME startup

Concern:

- This type of motion could indicate the presence of an environment outside design predictions or could be causing TPS or structural damage

Discussion:

- Review of ascent film for STS-100 detected tile/structure motion with transient second order harmonics on the left OMS pod at the aft lower corner following SSME ignition
- The right OMS pod also showed definite motion, but of lesser magnitude
- Review of flight launch films from 20 previous flights showed that movement may be discernible on two other flights, but to a lesser magnitude

OMS POD VIBRATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Discussion (Cont):

- The NASA JSC Image Science & Analysis Group performed film review analysis to define the amplitude and frequency of the LP04 pod movement
  - Two mid-panel points show 72-73 Hz oscillations with maximum peak-to-trough deflections of 0.7 inches (zero-to-peak amplitude of +/- 0.35 inches) in the out-of-plane direction

OMS POD VIBRATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Discussion (Cont):

- System Integration reviewed STS-100 environment data
  - Consistent with previous flight history
  - No detectable off-nominal Main Engine Ignition environments
  - Unable to make direct comparison to OMS pod design environment due to lack of instrumentation
- Stress analysis of OMS outer panel under acoustic loads predicts motions compatible with observations
  - Observed amplitudes are within MEI acoustic design environment predictions and capability – maintain 1.4 factor of safety for both structure and TPS
- No LP04 design differences or MR history that would be a cause for this pod having a unique dynamic response

OMS POD VIBRATION

Presenter: Mike Burghardt

Organization/Date: Orbiter/06-28-01

Actions Taken (cont):

- The OV-105 left OMS pod structure and TPS were inspected to ensure actual vehicle condition corroborate analytical findings
  - Two TPS tiles near peak amplitude location were removed and show no damage to tiles
    - For these same locations, ultrasound was performed of the outer side of structural panels and no de-bond or de-lamination was found
  - A third tile at the aft frame location (region of peak panel stress) was also removed
    - TPS inspection and ultrasound inspection of the outer structure was performed with no anomalies found
  - The pod stinger door was removed and borescope inspection of interior structure was performed with no anomalies found

OMS POD VIBRATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Actions Planned:

- Following LP04 pod removal, ultrasonic inspection will be performed on interior structure
- Options are being investigated to install strain gage instrumentation to quantify motion
  - Will determine if access permits after pod removal

Acceptable for STS-104 Flight:

- OV-105 STS-100 left pod response is within MEI acoustic design environment predictions and within design capabilities for both structure and TPS
- No LP04 design differences or MR history that would cause a unique dynamic response
- Affected TPS and OMS skin structure show no indication of failure

RADIATOR ISOLATION VALVE CIRCUIT BREAKERS ON PANEL L4

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Observation:

- Radiator isolation valve circuit breakers 137 and 138 on panel L4 are 5 amp, but should be 3 amp

Concern:

- The maximum current allowed by a 5 amp circuit breaker could cause an over-current shutdown of the associated inverter if a short in the circuit were to occur

Discussion:

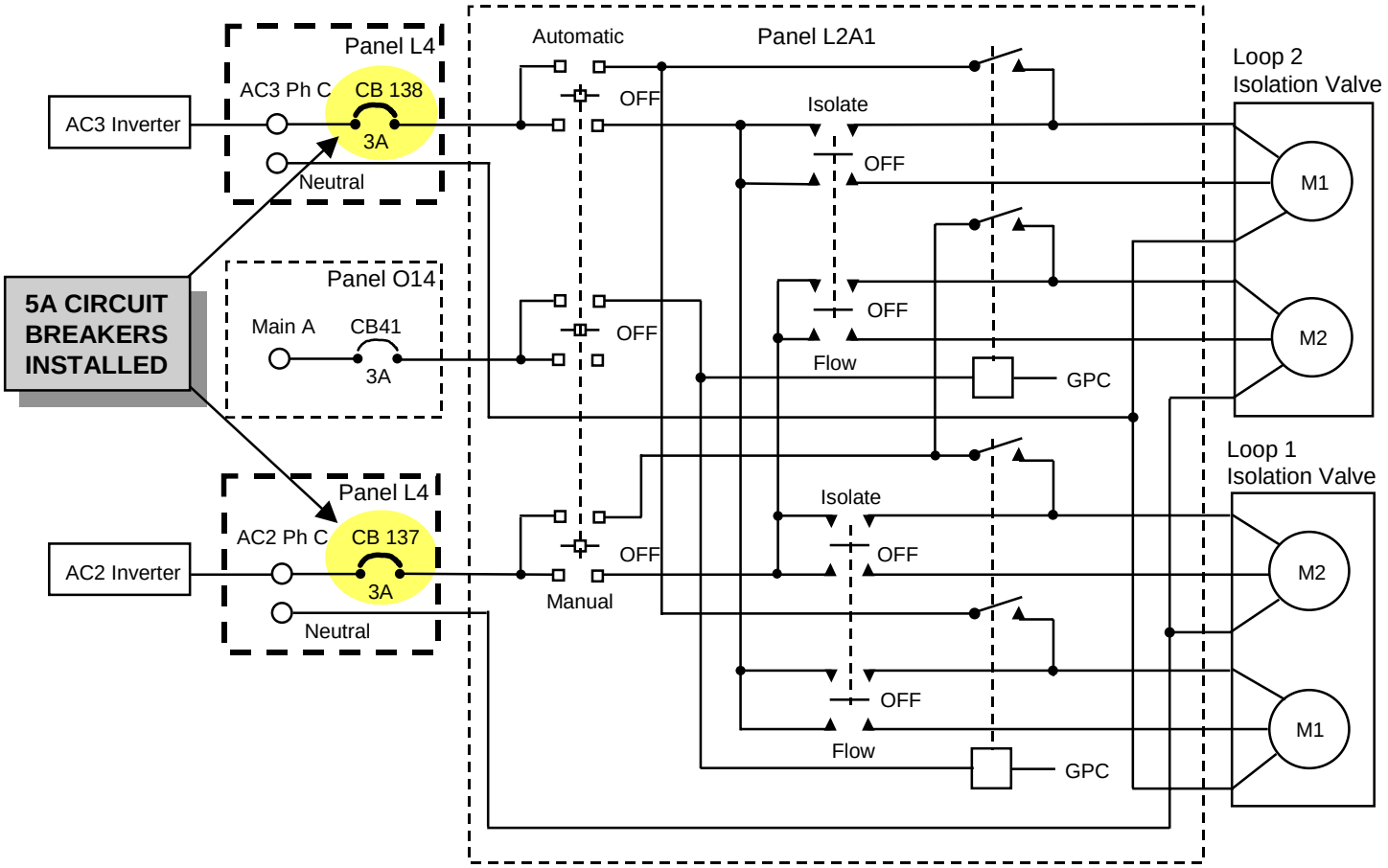
- Inverters 2 and 3 provide circuit protection and distribution of AC power through these panel L4 circuit breakers and then through panel L2A1 controls to the radiator isolation valve motors
- The ECN specifies a 3 amp circuit breaker; however, a 5 amp circuit breaker was called out in error on the EO to the assembly drawing

RADIATOR ISOLATION VALVE CIRCUIT BREAKERS ON PANEL L4

Presenter:
Mike Burghardt

Organization/Date:
Orbiter/06-28-01

Radiator Isolation Valve Circuit

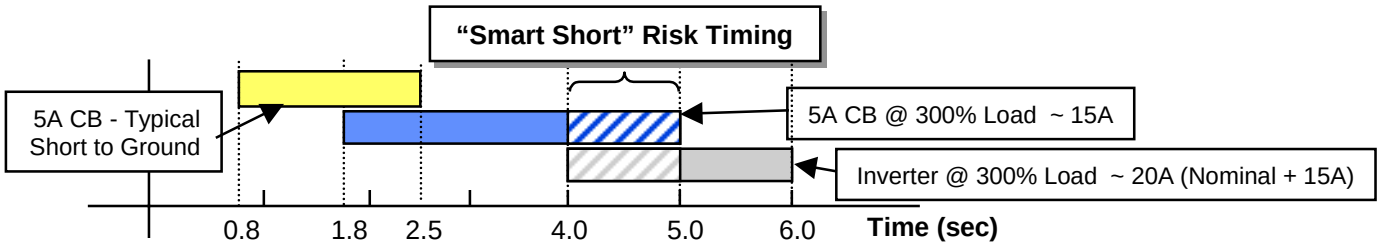


RADIATOR ISOLATION VALVE CIRCUIT BREAKERS ON PANEL L4

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Actions Taken:

- Circuit stress analysis verified wire is protected under present conditions
- Panel L4 wiring was inspected as part of hinged panel wire inspections - no discrepancies were found
- The OV-104 radiator isolation valves have been cycled to verify circuit integrity
- With a typical short to ground, the 5 amp circuit breaker will protect the circuit
  - A “smart short” (a limited current short that allows the inverter to overload before the circuit breaker trips) could result in an over-current shutdown of the inverter



RADIATOR ISOLATION VALVE CIRCUIT BREAKERS ON PANEL L4

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Risk Assessment:

- Since power to an isolation valve is only applied downstream of panel L2A1 in a contingency situation, exposure to risk of a short circuit is limited
- In the event an isolation valve must be closed, the 5 amp circuit breaker will protect for the most common short circuit condition
- For a “smart short” overload trip of the upstream inverter, flight rules require the circuit breakers for all downstream circuits to be opened resulting in loss of redundancy in multiple PLBD latch gangs
  - There is an existing IFM procedure which would isolate the shorted inverter and allow the 3-phase ganged circuit breakers to be closed restoring redundancy to PLBD latch functions on the remaining two phases
  - If these functions cannot be recovered by the IFM, the flight rules require a next PLS due to loss of PLBD function redundancy

RADIATOR ISOLATION VALVE CIRCUIT BREAKERS ON PANEL L4

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/06-28-01

Follow-on Actions:

- Following STS-104, 3 amp circuit breakers will be installed on vehicles equipped with the radiator isolation valve prior to next flight
- Process improvement currently in work at the Boeing H.B. design center to ensure closed loop check of drawings vs. ECN

Acceptable for STS-104 Flight:

- The functionality and integrity of the OV-104 radiator isolation valve circuits have been verified
- Exposure to risk is limited to contingency radiator isolation
- Under most short circuit conditions, the 5 amp circuit breaker will protect the circuit
- If the inverter is shutdown as a result of a “smart short”, an IFM procedure is in place to restore PLBD function redundancy

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

Observation:

- During disassembly to relocate/upgrade the cryo skid test stand at the NSLD, a hydrocarbon oil contamination was discovered

Concern:

- Hydrocarbon oil would be incompatible with LOX with potential impact ignition risk to installed LOX hardware processed through the test stand

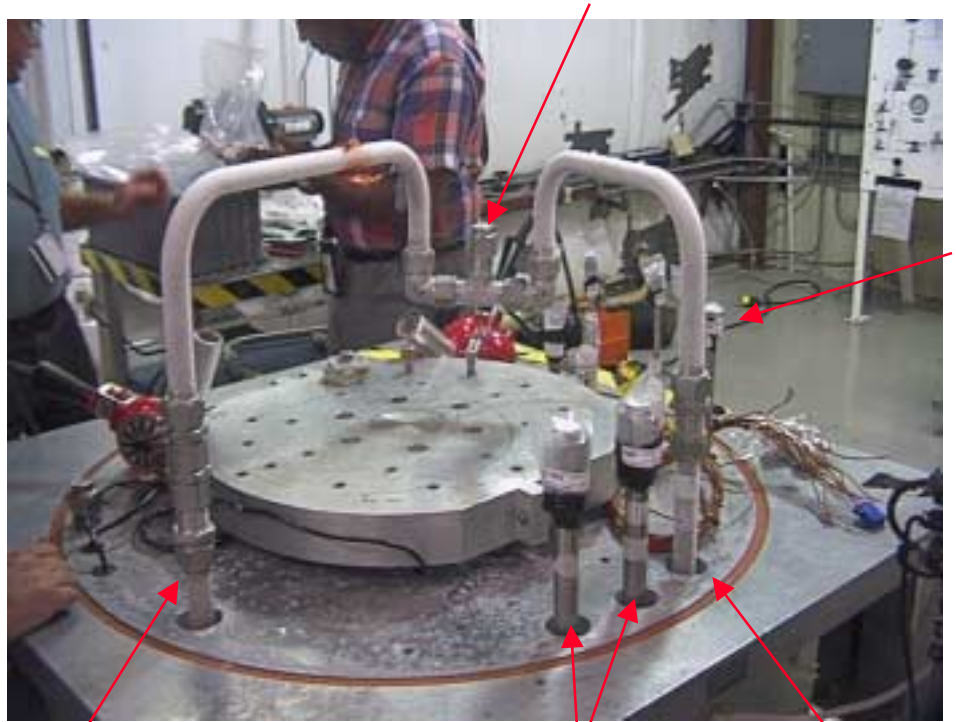
Discussion:

- Test stand certified for operation in 1991 and utilized to test LOX and LH_2 hardware in both MPS and PRSD subsystems
- Hardware tested
  - MPS 12” Prevalves
  - MPS 8” Fill and Drain valves
  - PRSD cryo valve panels (manifold isolation, reactant, and ECLSS supply valves)

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

NSLD CRYO SKID TEST STAND

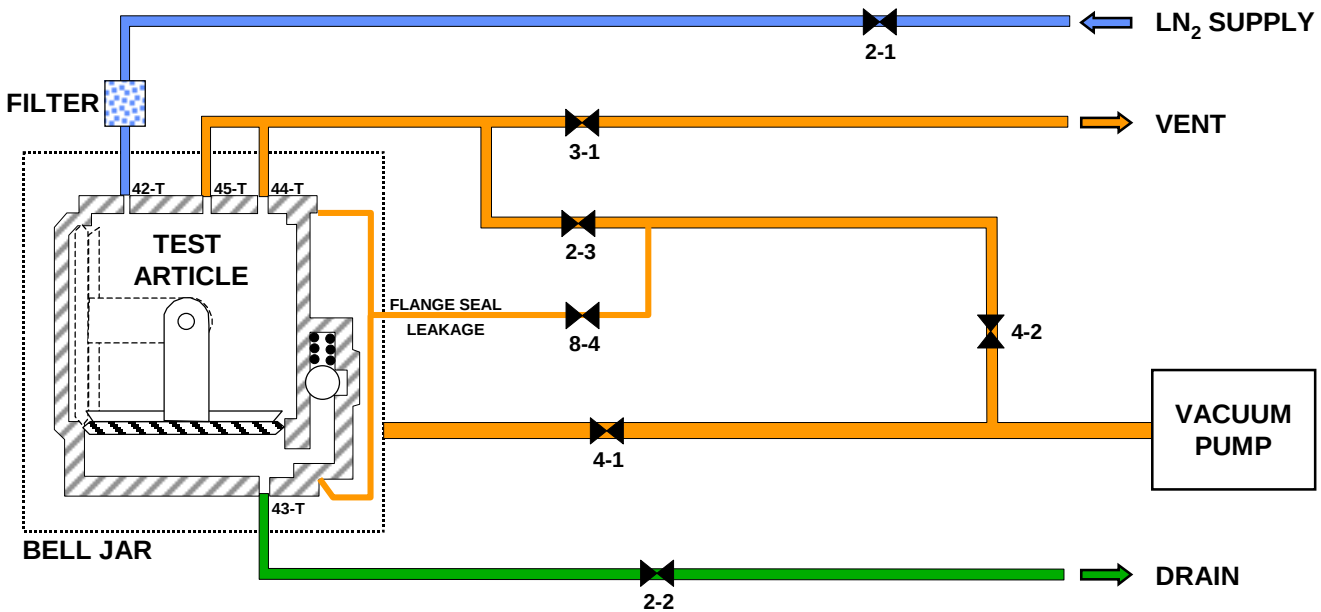


MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt

Organization/Date:
Orbiter/6-28-01

NSLD CRYO SKID TEST STAND SCHEMATIC



(Typical for MPS Component Testing)

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

Actions Taken:

- Performed analysis of contaminant
  - Determined to be double distilled pure hydrocarbon oil with paraffin from vacuum pump on test skid
- Evaluation of test stand configuration revealed a mechanism for oil migration to test articles
  - Pump seal leakage/back diffusion allows introduction of oil into vacuum lines
  - MPS Prevalve ATP exposes flight valve and LN_2 supply system to vacuum source providing path for oil migration
  - Subsequent testing of PRSD panels and MPS Fill and Drain valves exposes test articles to accumulated oil

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

Actions Taken:

- A series of tests were performed at NSLD to characterized the oil migration
  - Oil readily transported by LN_2 flow – At least 95% oil removal efficiency demonstrated for up to 100 mg of oil

Oil Introduced	1mg	5mg	10mg	20mg	100mg
Residual Oil	0mg	0.2mg	0.14mg	0.1mg	4.8mg

  - Oil accumulates on flex hose convolutes, test flanges and deadheaded lines – areas where LN_2 evaporates (vs. draining)
  - Oil does not accumulate in straight flow paths

Testing demonstrates that test flanges (low points) and interface flex hoses are representative of worst case oil accumulation on flight hardware

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

Actions Taken:

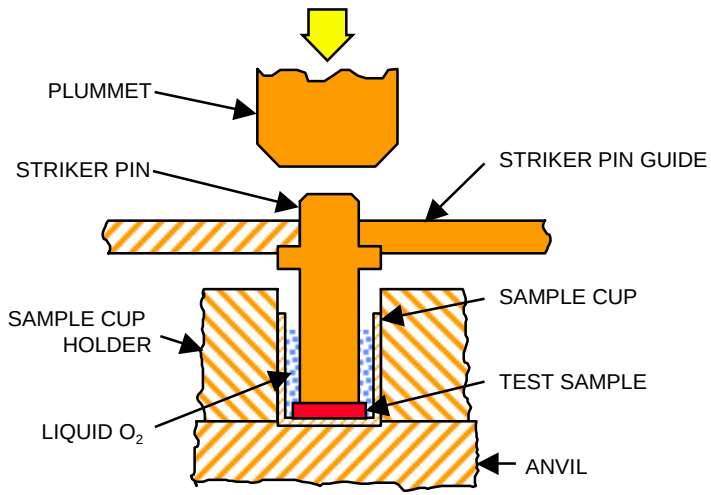
- Flushed test stand interface hardware to determine oil contamination levels
  - 1.3 mg/ft^2 on PRSD interface flex hoses last used 5/00
  - 2 mg/ft^2 on LOX 8” Fill/Drain test flange last used 12/00
  - 2.5 mg/ft^2 on LH_2 8” Fill/Drain test flange last used 4/01
- Determined hydrocarbon oil contaminant compatible with components in LH_2 system – LH_2 components cleared for flight
- Identified affected LOX components tested on this stand (22 total end items since 1991)
  - OV-104 has three of these components installed
    - Two MPS LOX 8” Fill and Drain valves (1/96, 11/97)
      - Three flights, six cryo loadings since installation
    - One LOX PRSD panel (11/93)
      - 11 flights since installation

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

Actions Taken (cont):

- Performed oxygen/ignition testing at WSTF to characterize volatility of vacuum pump oil in LOX and GOX
  - LOX ignition threshold is >10 ft-lbs impact on 2 mg oil
    - 2 mg oil equates to 778 mg/ft^2 concentration
  - Oil passed 1050 psi GOX mechanical impact testing at 30 ft-lbs impact on 2 mg oil



MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

Actions Taken (cont):

- MPS 8” Fill and Drain valves were evaluated
  - Flight hardware cannot be sampled for contaminant level nor flushed while installed, so determined maximum level of contamination on exposed test flanges, MPS Prevalve engineering test unit (ETU), and inlet of spare Fill & Drain valve
    - Maximum oil contamination was 2.5 mg/ft^2 on test flange (at least two orders of magnitude less than WSTF test threshold)
    - Negligible contamination on MPS Prevalve ETU last used 3/01
    - 1.2 mg/ft^2 on inlet of S/N 601 spare LH_2 Fill & Drain valve tested 5/01

Results consistent with NSLD testing that showed oil deposits where LN_2 evaporates vs. drains over a surface

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

Actions Taken (cont):

- MPS 8” Fill and Drain valves were evaluated (cont)
  - Evaluated sources of mechanical impact energy within the 8” Fill and Drain valve
    - With the exception of the valve needle bearings, all impact loads were $4x10^{-3}$ ft-lbs or less (multiple orders of magnitude less than WSTF test threshold)
  - Valve needle bearings support up to 14,000 lb load as blade is seated, so potential exists to ignite oil
    - Tight clearances and test orientation preclude deposit of oil sufficient to initiate a reaction
    - Race materials will not support combustion

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

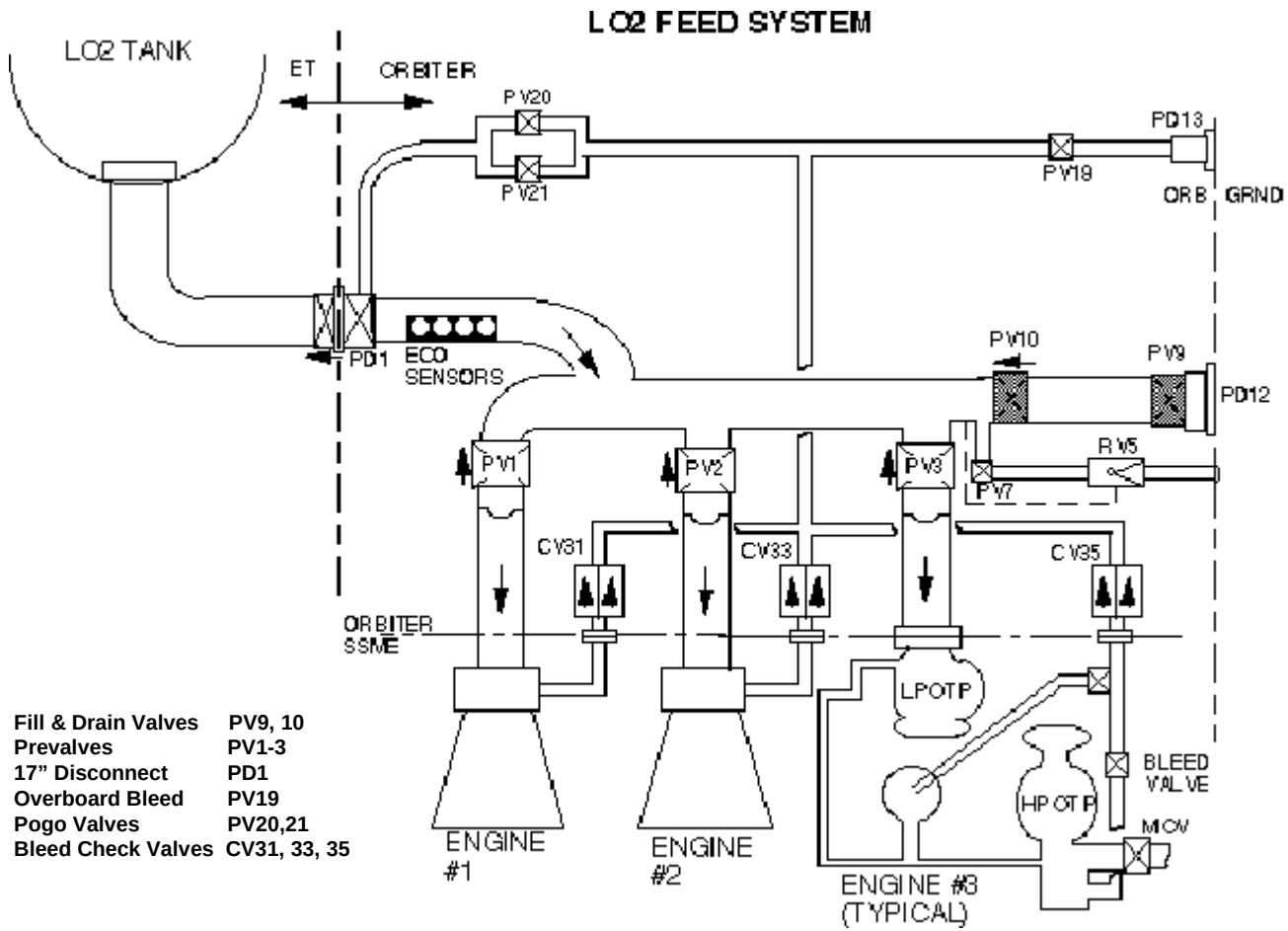
Actions Taken (cont):

- Due to concern for oil migration, components downstream of MPS 8” Fill and Drain valves were evaluated
  - Prevalves
    - Orientation of valve during flow and internal flow liner eliminate any credible modes for depositing solid oil contamination in the drive mechanisms
    - Worst case translational loads at valve seat are $2x10^{-4}$ ft-lbs
  - 17” Disconnect
    - No actuating mechanisms in the flow stream which present an impact concern
    - Non-credible for contamination to rest on seat at exact time of closure event
      - Even if this were to happen, closure of flapper is slowed by outflow of trapped, incompressible LO_2 resulting in extremely low closing forces

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt

Organization/Date:
Orbiter/6-28-01



Fill & Drain Valves	**PV9, 10**
Prevalves	**PV1-3**
17” Disconnect	**PD1**
Overboard Bleed	**PV19**
Pogo Valves	**PV20,21**
Bleed Check Valves	**CV31, 33, 35**

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

Actions Taken (cont):

- Evaluation of MPS downstream components (cont)
  - Overboard bleed valve – no mechanical impact sources
  - Pogo valves – no mechanical impact sources
  - Bleed check valves
    - No credible trap areas
    - Negligible closing loads when flappers close
  - External Tank
    - No concern – no mechanical impact sources
  - SSME
    - Coordinated with SSME – Although oil contamination is undesirable, expected quantity is acceptable for OV-104

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

Actions Taken (cont):

- Other sources of ignition within the MPS system were evaluated
  - No potential for ignition due to adiabatic compression since compression heating will not exceed auto-ignition temperature (AIT) of oil (278°F)
  - Ignition due to impact of oil contaminant striking a fixed object in the flow stream was also evaluated
    - WSTF experience has shown that particle impact ignition in LO_2 flow is not a concern
    - Oil will simply bounce off or will break up upon impact

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

Actions Taken (cont):

- PRSD valve panels were evaluated
  - Maximum level of contamination on test lines and spare valves was 1.3 mg/ft^2 (more than two orders of magnitude less than WSTF test threshold)
    - 1.3 mg/ft^2 on PRSD interface flex hoses last used 5/00
    - No detectable level of vacuum pump oil on seven spare PRSD valves (four exposed in 1994/1995 and three exposed in 1999)
  - Evaluated sources of mechanical impact energy within the PRSD panel - maximum impact loads 0.1 ft-lbs
    - Two orders of magnitude less than WSTF test threshold
  - No concern for ignition due to adiabatic compression since compression heating will not exceed auto-ignition temperature (AIT) of oil (278°F)
  - Thermal analysis shows that three system failures would be required for valve solenoid energy heating to exceed AIT of oil

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

Actions Taken (cont):

- Components downstream of PRSD panels were evaluated
  - Fuel Cell
    - Fuel cell preheater (heat exchanger) warms cryo O_2 to the gaseous state
      - Any oil particles in cryo O_2 will become droplets in gas and deposit on preheater fins or 90° bend at preheater exit
      - Industry data shows migration of oil deposited as a thin film in gas flow will not migrate farther at PRSD system flow rates
    - Even if a small quantity of oil were to migrate farther, still no concerns
      - Flow restriction not feasible
      - No mechanical impact energy at regulator
      - Vendor confirms negligible effect on fuel cell performance

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

Actions Taken (cont):

- Components downstream of PRSD panels were evaluated (cont)
  - ECLSS O_2 Pressure Control System interface
    - Oil contamination migration from the PRSD cryo O_2 system is unlikely
      - Tortuous path through a 25 micron O_2 filter and an O_2 restrictor (~1 lb/hr nominal; 25 lbs/hr max per system)
    - O_2 Restrictor/Freon Heat Exchanger warms cryo O_2 to the gaseous state
      - Any oil particles in cryo O_2 will become droplets in gas and deposit on Lee Jet flow restrictor
      - Industry data shows migration of oil deposited as a thin film in gas flow will not migrate further at ECLSS system flow rates
    - Recent ARPCS component rework at vendor has shown no evidence of hydrocarbon contamination (NVR verified by test)

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

Risk Assessment:

- The consequences of sustained ignition within MPS and PRSD system due to hydrocarbon oil reaction with LOX is unacceptable
  - Risk is avoided for each of the potential event initiators:
    - Mechanical impact
      - Fill & drain valve needle bearing configuration and material cannot sustain reaction
      - Remaining components cleared by comparing impact energy and potential contamination level to WSTF test threshold
    - Particle impact
      - Insufficient energy
    - Ignition due to adiabatic compression
      - Compression heating will not exceed auto-ignition temperature (AIT) of oil (278°F)
    - Solenoid energy
      - Three system failures would be required for heating to exceed AIT of oil

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

Acceptable for STS-104 Flight:

- OV-104 MPS system is acceptable for flight
  - Black light inspections prior to installation and prior to each flight have not detected oil
  - Concentrations of oil found to date at NSLD are enveloped by WSTF impact testing
  - Testing experience has shown that this oil is easily liberated under cryogenic flow conditions
    - Hardware which has already flown is most likely clean
  - Relatively few locations where trapping or collection of oil is considered credible
  - Impact energies for MPS mechanical hardware are multiple orders of magnitude below WSTF testing
  - Ignition due to flow stream impacts on fixed hardware considered non-credible
  - No risk of ignition due to adiabatic compression

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

Acceptable for STS-104 Flight:

- OV-104 PRSD and ECLSS systems are acceptable for flight
  - No measurable amount of oil in PRSD spare valves
  - Concentration of oil found on test flex hose at NSLD is enveloped by WSTF impact test threshold
  - Impact energies for PRSD mechanical hardware are two orders of magnitude below WSTF test threshold
  - No risk of ignition due to adiabatic compression or energy transfer from solenoids
  - No mechanism for oil migration beyond fuel cell preheater or ECLSS flow restrictor where O_2 changes state from liquid to gas
    - No flow or performance concerns with these small quantities of oil
    - No mechanical impact energy between PRSD cryo panel and these components

MPS/PRSD CRYO SKID TEST STAND OIL CONTAMINATION

Presenter:
Mike Burghardt
Organization/Date:
Orbiter/6-28-01

Follow On Actions:

- Development of cleaning procedure
- Vacuum pump and test configuration evaluation will be performed to determine leakage path and specific transport mechanism
- Other NSLD vacuum applications have been evaluated – no other test configuration exposes LOX hardware to vacuum oil
  - Evaluation in work to determine if any other hardware is at risk due to vacuum pump oil
- Communication with vendors to evaluate potential for similar contamination

ALCA #3 Power Connector Lugs

Presenter:
Mike Burghardt

Organization/Date:
Orbiter/06-28-01

Observation:

- Wire lugs that are terminated at the power and return pins of connector J5 are very close together

Concern:

- A potential for a short circuit exists should the two conductors make contact

Discussion:

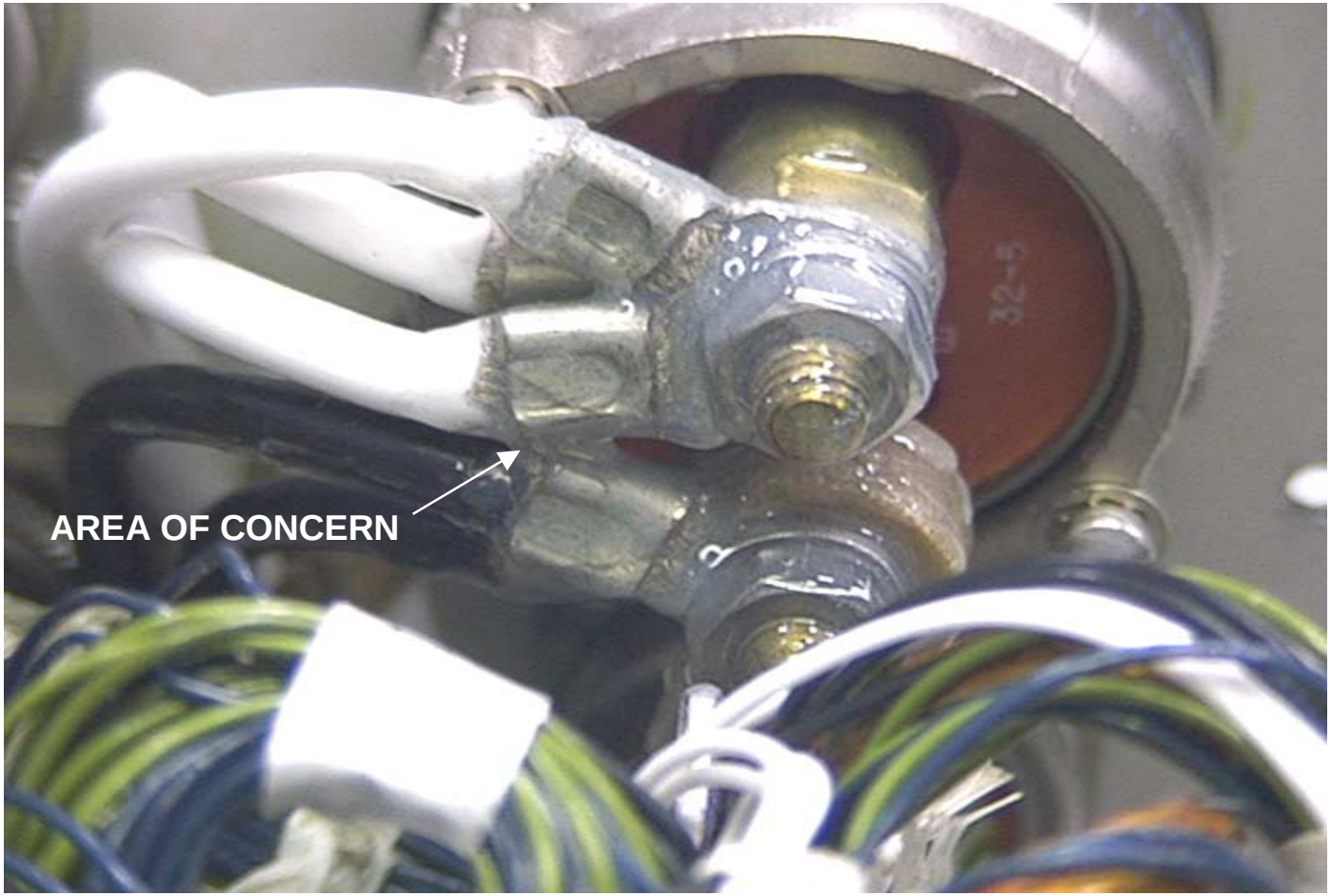
- Aft Load Control Assembly (ALCA) #3, S/N MYH0001 was undergoing repair for a failed hybrid driver when this issue was identified
  - Visual inspections have determined wire lug separation to be approximately 0.080 inches
- ALCA #3 is the OV-102 original build unit delivered in 1978 and has extensive flight exposure
  - From ’81 - ’92 it flew 10 flights on OV-102 & OV-103
  - From ’94 - ’01 it flew 11 flights on OV-104

ALCA #3 Power Connector Lugs

Presenter:
Mike Burghardt

Organization/Date:
Orbiter/06-28-01

ALCA #3 (S/N MYH0001) CONNECTOR J5 INTERNAL CONNECTIONS



ALCA #3 Power Connector Lugs

Presenter:
Mike Burghardt

Organization/Date:
Orbiter/06-28-01

Actions Taken:

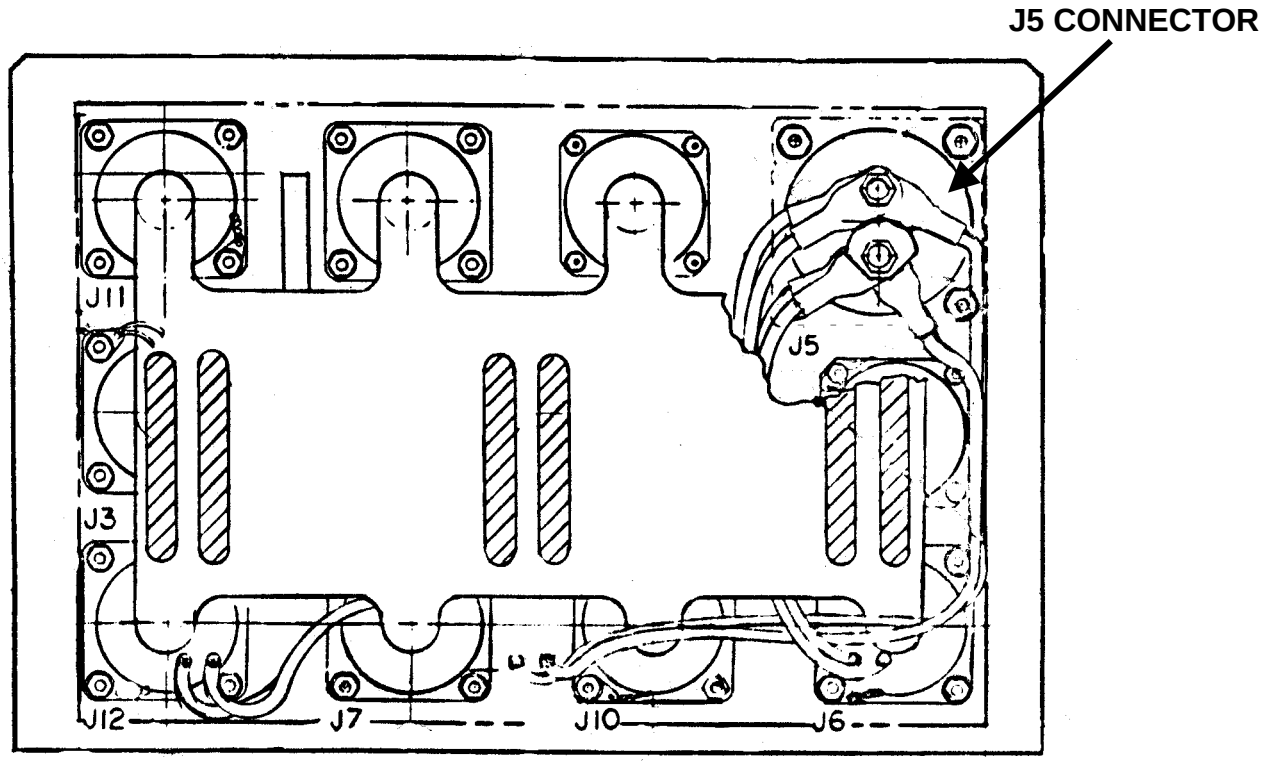
- Found wire routing was not per assembly drawing
  - Drawing shows one of three wire lugs should be attached from opposite side of J5
  - Although drawing does not specify minimum lug separation, good shop practice is expected
- Reviewed original build data package – no indications of deviations from wire routing requirements per the drawing
- Assessed condition of RTV coating between lugs on S/N MYH0001
  - NSLD reported a solid RTV bridge indicating that there has been no movement or migration of the two lugs in question
- Evaluated other EPDC LRUs to determine if this condition may exist elsewhere – only the ALCAs employ this wire termination design

ALCA #3 Power Connector Lugs

Presenter:
Mike Burghardt

Organization/Date:
Orbiter/06-28-01

J5 WIRE ROUTING DIAGRAM FROM DRAWING



ALCA #3 Power Connector Lugs	Presenter: Mike Burghardt
	Organization/Date: Orbiter/06-28-01

Actions Taken (cont):

- Since wire lug separation was not specified in the original ALCA build paper, the PRT identified a relevant DoD military standard and used it to establish an acceptance criteria
  - MIL-STD-454K (dated 2/14/85) specifies a minimum separation of 0.250” for the ALCA application (i.e., 32VDC at 100 Amps max.)
- Inspected available flight ALCAs for the following:
  - RTV bridge between lugs – shows lugs are still in the as-built location and have not rotated
  - Lug spacing of at least 0.250” and J5 harness routed per print – demonstrates adequate spacing to ensure no potential for short circuit exists
  - J5 stud nuts properly torqued – prevents lug from rotating around stud
  - J5 wires undamaged - ensures wire condition is not a contributor to potential for a short circuit

ALCA #3 Power Connector Lugs

Presenter:
Mike Burghardt

Organization/Date:
Orbiter/06-28-01

SUMMARY OF ALCA VISUAL INSPECTIONS

LRU	RTV Bridged	Lug Spacing ≥0.250"	J5 Wire Harness Routed Per Print	J5 Studs Properly Torqued	J5 Wires Undamaged	Comments
ALCA #3 MYH0001	Yes	**No** (~.080)	**No**	Yes	Yes	J5 stud fasteners retorqued following re-work
ALCA #1 Flt Spare	Yes	Yes	Yes	Yes	Yes	J5 stud lock washer was compressed
ALCA #2 Flt Spare	Yes	**No** (~.150)	Yes	Yes	Yes	RTV missing from the end of one stud, but RTV between lugs was good. Stud fasteners re-torqued following rework
ALCA #1 OV-105	Yes	Yes	**No**	Yes	Yes	J5 stud lock washer was compressed
ALCA #2 OV-105	Yes	**No** (~.080)	**No**	Yes	Yes	J5 stud fasteners to be retorqued following re-work
ALCA #3 OV-105	Yes	Yes	Yes	Yes	Yes	Found chaffed wire due to interference with LRU cover rib stiffener (mystic tape MR). J5 stud lock washer was compressed

ALCA #3 Power Connector Lugs	Presenter: Mike Burghardt
	Organization/Date: Orbiter/06-28-01

Actions Taken (cont):

- Engineering analysis concluded that the J5 connector lugs would have to be less than 0.005 inches apart, with no RTV present, before an arc-over event can occur
- All flight LCAs undergo Acceptance Vibration Testing which is 5dB higher then vibration environment predicted during a mission
  - Review of the failure history for OV-104 installed LCAs found no vibration related failures
- OV-104 installed LCAs have successfully flown over 11 missions with no unexplained anomalies or anomalies of this nature

ALCA #3 Power Connector Lugs

Presenter:
Mike Burghardt

Organization/Date:
Orbiter/06-28-01

Actions Taken (cont):

- Performed a system assessment to identify the risk associated with the loss of an ALCA – two subsystems have significant impacts
  - MPS
    - Loss of ALCA #1 or ALCA #2 during the countdown results in a launch scrub – requires tank boil-off
    - Loss of ALCA #1 or ALCA #2 between T-0 and MECO+2 minutes requires cycling between OPS 1 and OPS 3 to inert hydrogen manifold - may postpone docking
  - RCS
    - Loss of ALCA #3 causes loss of aft manifold 3, 4 & 5 thruster heaters and loss of manifold 5 isolation
      - With loss of heater, normal course of action is to fire thrusters to prevent leakage
      - Use of up-firing jets during docked operations is not acceptable, so unique manifold management required
      - With leaking aft vernier, could ultimately lead to requirement to close tank isolation valve

ALCA #3 Power Connector Lugs	Presenter: Mike Burghardt
	Organization/Date: Orbiter/06-28-01

Risk Assessment:

- Worst case criticality for an ALCA is 1R2
- Loss of an ALCA would affect numerous subsystem functions (e.g., APU, MPS, Hyd, FES, etc.)
  - Flight rules are in place to address these conditions
- Circuit protection (100A fuse) is employed upstream of the ALCAs to guard against short circuit conditions

ALCA #3 Power Connector Lugs

Presenter:
Mike Burghardt

Organization/Date:
Orbiter/06-28-01

Acceptable for STS-104 Flight:

- Voltage crossover can only occur with less then 0.005” separation
  - Results of ALCA inspections indicate that there has been no migration of the J5 terminal lugs (i.e., good RTV bridge, stud bolt torque, etc.)
  - All flight units have successfully passed vibration testing at 5dB higher than predicted flight environments
- Despite less than ideal J5 wire terminations, the existing configuration has successfully supported over 100 missions
- Redundant buses exist to power all critical functions
- OV-104 installed ALCAs have no UAs or anomalies of this nature

ALCA #3 Power Connector Lugs	Presenter: Mike Burghardt
	Organization/Date: Orbiter/06-28-01

Follow-on Actions:

- While ALCAs are considered acceptable for flight, the inspection data showed that several units were not per print – the PRT concluded that the condition of remaining flight units should be investigated
- The EPD&C PRT is developing a follow-on plan to inspect/rework J5 connectors associated with all ALCAs in the fleet
  - Plan to impose MIL-STD-454K inspection requirement on the NSLD via IDMRD

GFE

Topics	Briefer
ODS Mechanism Fixer	Stu McClung
NSI Weld Washer Contamination	Todd Hinkel
FLU-9 Water Activated Pyro Failure	Paul Shack

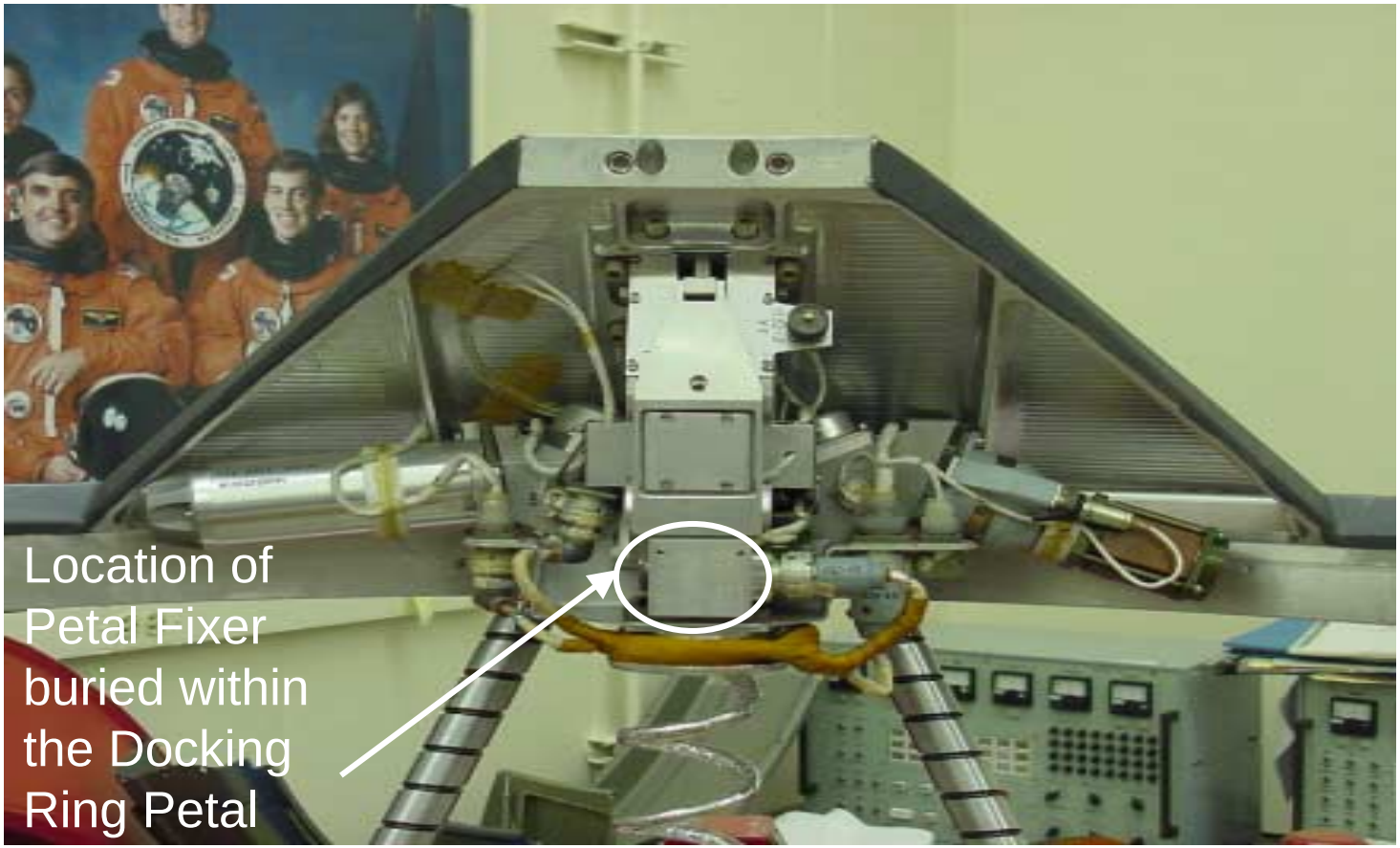
ODS Mechanism Fixer

- **Problem**
  - During routine OPF testing, Fixer #1 failed to engage
    - RSC-E representative was present and verified failure

- **Background**
  - Fixer limits ballscrew rotation, to maintain alignment of mating interface during extension or retraction
  - If fixer failed to engage during retraction sequence, potential loss of ability to complete docking
  - 5 Fixers on each mechanism. 3 on docking ring, 2 in differential
    - Tested each OPF flow. 8 Mir missions, 9 ISS missions, no previous failures
    - Numerous Brassboard tests, no failures noted
  - RSC-E stated that the design is essentially the same as was used in ASTP, and is used on other mechanisms. First recorded failure

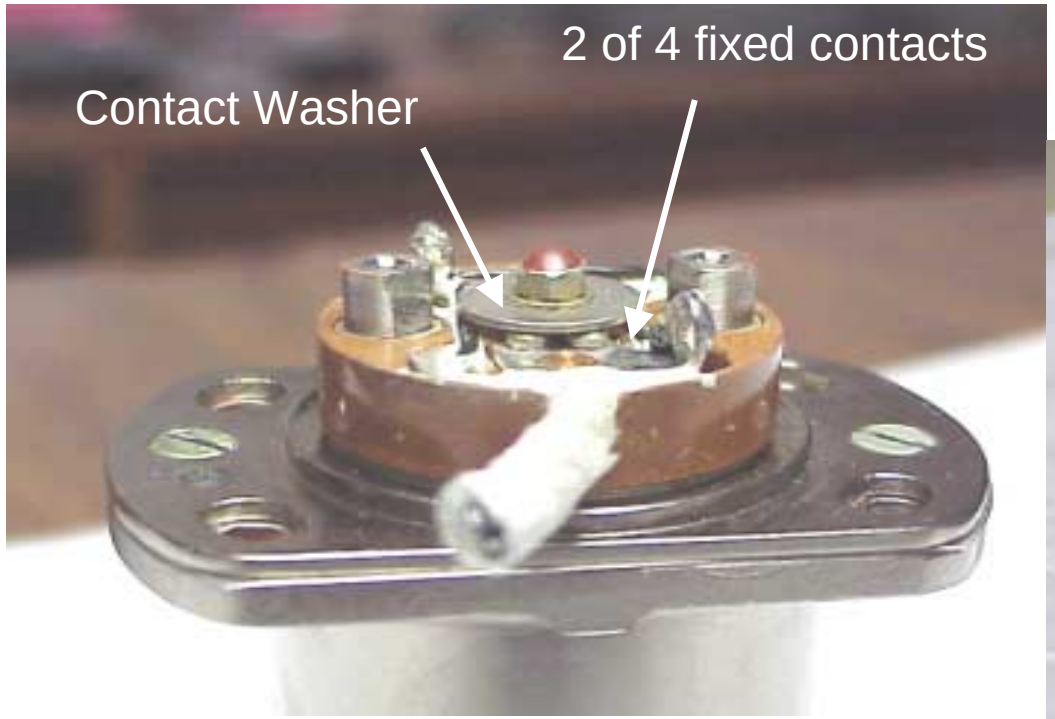
ODS Mechanism Fixer

View looking outboard from ODS center



ODS Mechanism Fixer

Fixer Contact Washer Subassembly



External view of Fixer

ODS Mechanism Fixer

- **Discussion**
  - Troubleshooting isolated failure to the Contact Washer Subassembly
    - Switch was stuck in the open position - unable to apply start up current to fixer
    - This Contact Washer Subassembly is common to all ODS Fixers
  - Assembly level tests of the fixer performed at RSC-E. Fixer was completely disassembled and piece parts inspected.
  - Approximately 100 cycles were applied.
    - Anomaly repeated 1 time
    - RSC-E attempted to repeat the failure by manipulating the Contact Washer Switch but was unsuccessful
  - Analysis findings:
    - 0.006 difference in contact heights
    - Contact washer sub assembly had some misalignment
    - Contact washer sub assembly could rotate on its axis
  - RSC-E conclusion is that all three findings combined to result in the failure.
    - Additional discussion has identified that the manufacturing tolerances are insufficient – design changes for future builds under review

ODS Mechanism Fixer

STS-104 Flight Rationale

- RSC-E performed R&R on May 8 and 9, new fixer installed and functioned properly, remaining ODS testing completed with no issues

- This failure can not result in a fixer failing on
  - Failed on fixer could result in hardware damage, due to non-compliant mechanism
- Failed fixer is only an issue when the docking system experiences energy (momentum) buildup within the kinematic chain resulting from a stuck damper, which can create significant (4% to 7%) linear misalignment
- Current flight procedures require crew to stop ring motion if RING ALIGN light on AFD panel goes out. Limits linear misalignment to 3% prior to motion stop
- Natural stiffness of system will realign the ring
- Current experience is that realignment motion unsticks dampers
- Fixer failure is unlikely, operational controls in place.

- ODS is ready for STS-104

NSI Weld Washer

Presenter: EP5/ Todd J. Hinkel

- **Problem**
  - Residual Etching Material Trapped between NSI Weld Washer and NSI Flange May Lead to Loss of Hermetic Seal for Pyro Assemblies on Installed Flight Hardware
    - Moisture Contamination is Concern for Propellant/Explosive Materials
    - Seal Leak Rate Requirement is < 1X10-6 sccs He
    - Condition Cannot Be Inspected after Installation
    - JSC GFE PRACA Problem Report JSCEP0201 Open on Contamination

- **Recommendation**
  - Not a Flight Constraint Based Upon Dual Seal Design Performance and History of Process
  - Screen Future Flight Kits
  - Implement a Permanent Corrective Action Eliminating Entrapment of Material on Weld Washer

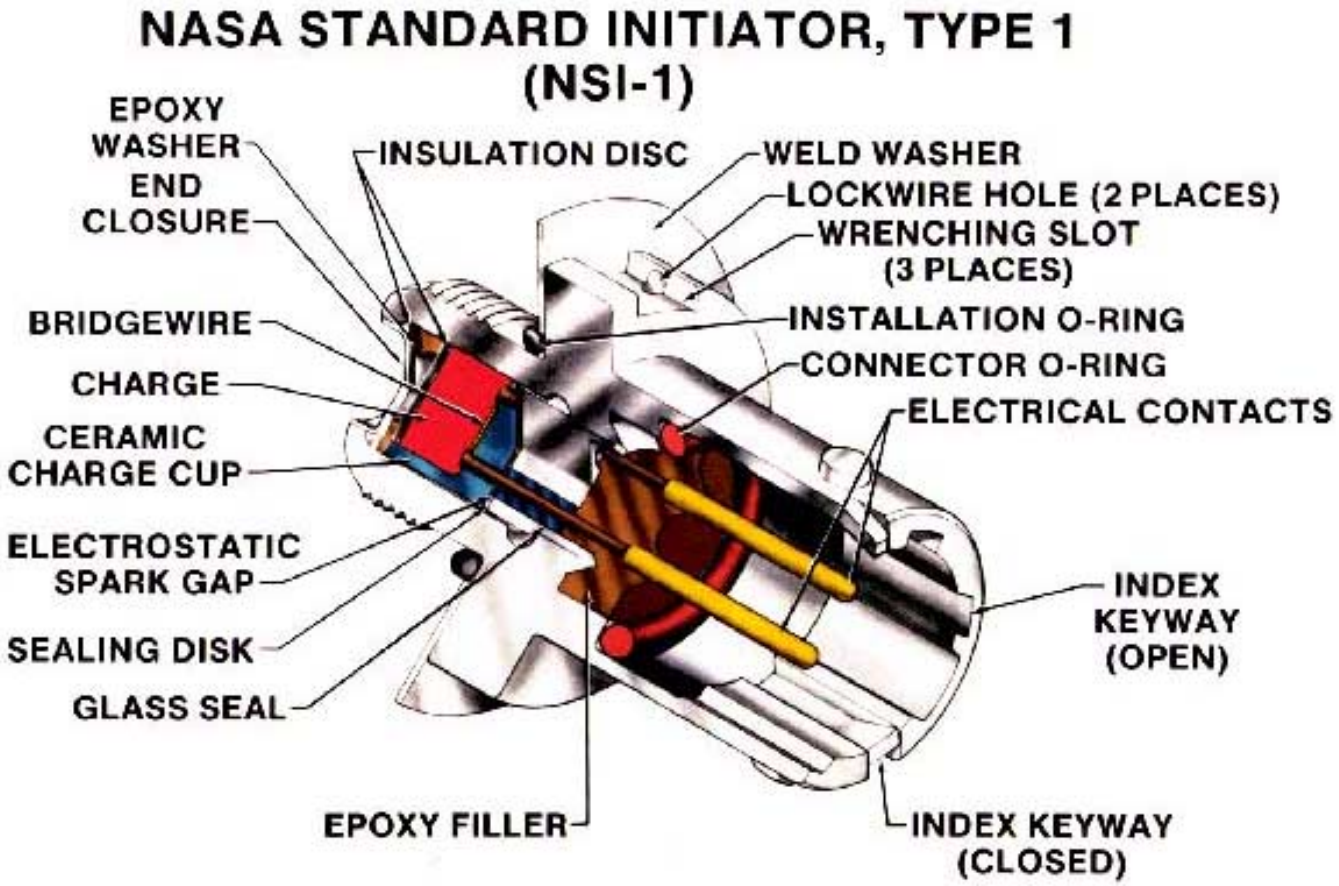
NSI Weld Washer

- **Background**
  - 137 NSI's Installed on Space Shuttle Vehicle and MLP
    - 102 Fired Every Flight/86 Use Weld Washers
    - 35 Installed in Emergency/Backup Applications/22 Use Weld Washers
  - KSC Stores NSI's for Program and Performs Etching Operation
    - KSC Configures NSI-Connector Keyway and Etches Dash Number of Configuration onto NSI Flange Prior to Shipment to Vendor
  - Etching Required per NSI Drawing to Reflect Final Connector Key Configuration
    - Procedure for Etching Developed at KSC (>30 Years Ago)
  - Contamination on NSI's Noted in Past
    - Leading to Removal and Replacement of Initiators from Assembled Hardware
  - Problem Historically Considered Screenable Through Visual Inspection
    - New Evidence Reveals Visual Inspection Alone is Inadequate for Detection of Trapped Solution
  - Condition Has Likely Existed on Flight Hardware Throughout Entire Program
  - Etching Solution Attacks Weld Washer (347 Stainless) and Causes Pitting In Material
    - Material is 0.005": Pitting Measured to 0.002" After Approximately 2 Months
  - Cannot Certify Integrity of Flight Inventory Weld Washers

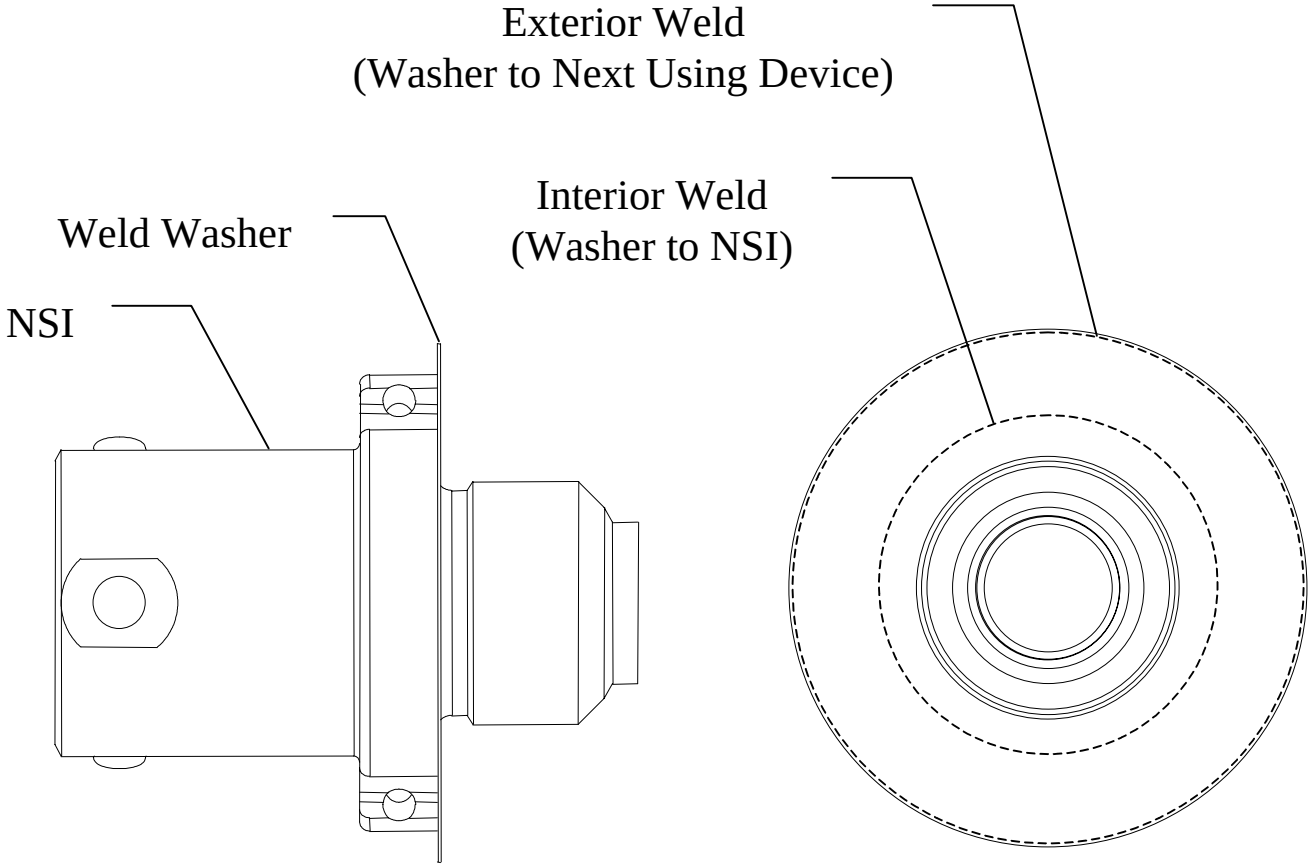
NSI Weld Washer

- **Background Continued**
  - Weld Washer Provides Two Functions
    - Hermetic Seal Between NSI and Next Using Device
      - Required Leak Rate < 1X10-6 sccs He
    - Thread Lock for NSI
  - NSI Has an O-Ring Installed on Each Next Using Device
    - O-Ring Provides a Secondary Environmental Seal
  - Two Threaded-Port Configurations Exist in Space Shuttle Pyro Hardware
    - MS16142 and MS33649
    - Both Provide O-Ring Sealing Gland Capable of Meeting Leak Requirement
    - O-Ring is Not Verified on All Hardware Due to Configuration Restrictions
    - Final Assembly is Leak Tested

NSI Weld Washer



NSI Weld Washer



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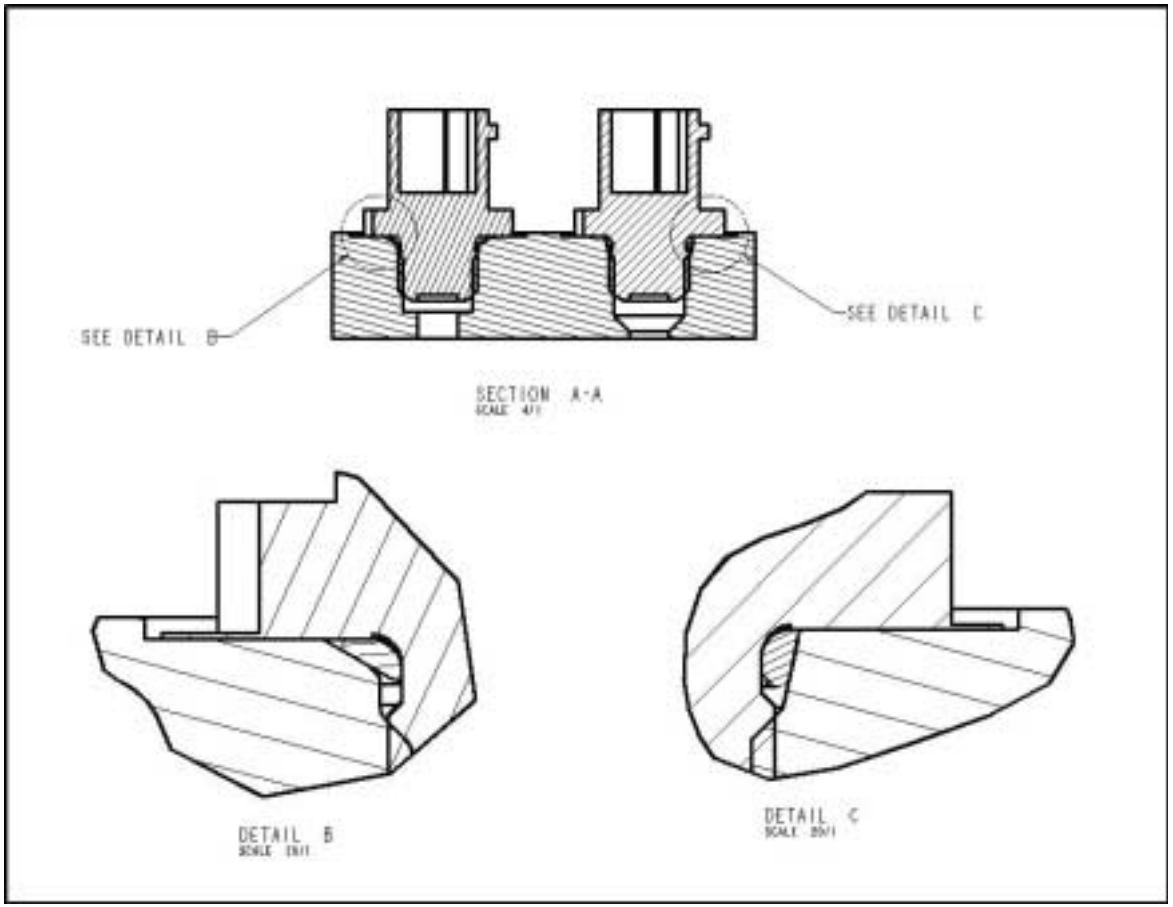
NSI Weld Washer

Presenter EP5/ Todd J. Hinkel



MS33649 Port MS16142 Port

VE-42.7.13

NSI Weld Washer

- **Pyrotechnic Hardware is Subjected to Age Life Testing per NSTS 08060**
  - **5 Samples Selected from Flight Lot 4- and 7-years After Acceptance**
  - **Destructive Performance Testing Conducted to Verify Hardware Output**
  - **No Anomalous Performance Has Been Identified in History of Program Attributable to Environmental Contamination of Hardware**

NSI Weld Washer

- **Testing Completed to Date**
  - He Leak Testing of Post-Flight and Post-Test Hardware Show the O-Ring Alone Provides <1X10-8 sccs He Leak Capability
    - 58 Tests of MS33649 Ports; 1 “Leaker” Noted
    - 64 Tests of MS16142 Ports
  - Disassembly of the “Leaker” Noted Contamination Interior to the NSI Stitch Weld Diameter
    - Appears to be Evidence of O-Ring Blow-By
  - Analysis of the “Leaker” Contamination Performed by EM
    - Results are Inconclusive
  - 10 Units That Passed the He Leak Test With the MS33649 Port Configuration Were Disassembled
    - No Indication of Blow-By Detected
  - “Leaker” Was Reassembled and Re-tested With the Same Components
    - Tests Yielded a Leak Rate <1X10-8 sccs He

NSI Weld Washer

- **Testing Completed to Date Continued**
  - He Leak Testing Performed on Both Port Configurations with Damaged O-Ring
    - O-Ring Completely Severed in One Location and Cut ~90% Through at Another Location
    - Significant Gouge Through the Cross Section (33% of Diameter x .125”)
    - All Tests Met the Required Leak Rate <1X10-6 sccs He
  - Propellant Stability Testing Performed in ‘95 on Lead Azide and RDX
    - Considered “Middle-of-Road” Concerning Hygroscopic Qualities for Propellants Flown
    - Propellants Subjected to Several Cycles of an Elevated Temperature Vacuum Bake Followed by Exposure to an 85% Relative Humidity Environment at Ambient Temperature
    - No Performance Degradation Witnessed After Exposure

NSI Weld Washer

- **STS-104 Flight Rationale**
  - **NSI O-Ring and Two Port Configurations Provide Leak Rates Which Meets, or are Better than the Required Specification**
    - **<1X10-8 vs. 1 X10-6 sccs He**
  - **Age Life Testing of Shuttle Hardware Performed to Verify Lot Performance**
    - **Representative Samples from Lot are Selected for Testing**
    - **No Problems Have Ever Been Identified Attributable to Environmental Intrusion into Pyrotechnic Assemblies**
  - **Pressure Cartridges Flown are Designed to Function with 85% of Nominal Propellant Load**
  - **Each Critical Application has Redundant Cartridges**
    - **Exception is Main Gear Uplock Release Cartridge, Drag Chute Mortar Cartridge**
  - **No Flight Function Failures Experienced with the Pyrotechnic Hardware**

STS-104 Flight Readiness Review

FLU-9 Water Activated Pyro Failure

June 28, 2001

Description & History

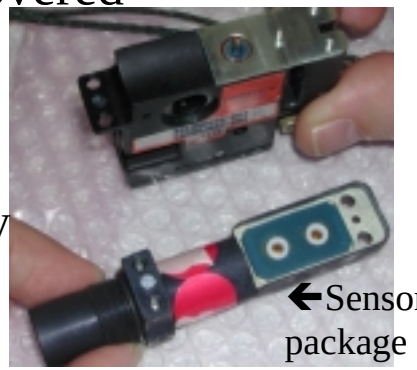
- FLU-9 is a pyrotechnic device installed on the life raft
- Pyro is automatically activated upon water entry to partially inflate the Crew Escape life raft by puncturing 1 CO2 cylinder (life raft is fully inflated by manually activating a second CO2 cylinder)
- Upon water entry during training 1 unit fired improperly
  - Pyro discharged but failed to puncture CO2 bottle
  - External housing cracked and vented to ambient
- During testing at the vendor of 1997 lot flight units to assess this failure, 2 additional units fired inadvertently
  - 1 unit during bleed resistor testing (S/N 234)
  - 1 unit during Electro Static Discharge (ESD) testing (S/N 236)
- Although no failures have been seen with FLU-8 devices (pyros used in the life preserver unit), similarity to the FLU-9s make them subject to the same issues

Investigation

- FLU-9s available in JSC inventory (47 1992 units (expire 6/30/01) & 12 1997 units) were returned to vendor (Conax) for analysis
- Unit that failed during training (1992 unit) was disassembled
  - Failure points toward defective stainless steel stock used in primer plugs in the 1992 FLU-9 units
  - Metallurgical analysis indicates a higher hardness rating for the 1992 units and sites ductile failure from tensile loads as the root cause
- S/N 234 was disassembled and a cracked resistor was discovered
  - Resistor appears to have cracked due to the shock imparted by activation of the pyro (Conax has seen this condition in the past on other units)
  - Proper procedures were not followed by vendor during handling, testing, etc.
    - Test facility and technician were not properly grounded
    - Rubber gloves were used in handling the pyro (gloves should not be worn)
  - Most likely cause of premature firing is static electricity generated by procedural errors
  - Preliminary analysis shows failure may be unique to the handling of this particular unit, but the issue is still under investigation

Investigation

- S/N 236 was disassembled and a damaged wire was discovered
  - S/N 236 failed/fired the pyro during ESD testing at 25 kV
  - Sensor package was removed and integrated to the body of a different pyro and the failure was repeated
  - Sensor resistor and capacitor testing showed no discrepancy
  - X-rays showed a potential location of wire contact which was investigated
    - Additional X-rays were taken from various angles to determine if there was contact, however the results were inconclusive
  - Sensor package was disassembled and a sharp edge was discovered on an electronics socket that cut into the teflon coating of the battery contact wire
  - Contact provided a path allowing failure of the unit during ESD testing



←Sensor package

- Additional analysis is being performed
  - Investigating failure paths of the electronics sensor housing
  - Determining if static discharge is a credible failure in Crew Escape applications

Flight Readiness Options

- Fly current units as-is
  - Requires metallurgical analysis to clear primer plugs used in 1997 lot
  - Requires root cause establishing ESD failures to be isolated cases not applicable to Crew Escape Equipment
  - Decision should be made by July 2nd in order to not impact parallel path efforts

- Screen the currently available flight units
  - Requires proving that testing adequately screens for the ESD problem
  - Remove FLU-9s already in parachute packs at KSC
    - Replace with 1997 units that have already been fully screened
    - Targeting replacement to occur July 5-7
  - FLU-8 units attached to life preservers at KSC will also be changed out
    - Replacement with fully screened units would occur during launch week and would present minimal impact

Back-Up Charts

Cracked Primer Plug

- Unit that failed during training (1992 unit) was disassembled
  - Crack was found in the primer plug, which houses the primer containing the pyro charge
  - Allowed charge to not properly puncture the end of the primer and gas expelled in the reverse direction, thus causing damage to the housing
- Cracks were found in 5 additional 1992 units, all exhibiting the same failure pattern
- No cracks were noted in any of the 1997 units
- Different stainless steel lots and suppliers were used in the 1997 builds
- Failure points toward defective material stock used in 1992 builds
- Metallurgical analysis of stainless steel used in the 2 lots notes hardness differences between lots and sites ductile failure by tensile loads as the root cause of the 1992 lot unit cracks
- No history of this type of failure previously exists
- Backup manual activation system is unaffected by this type of failure

FLU-8/FLU-9 Flight History

FLU-9

- 1997 lot unit FLU-9s started being packed in Parachute Packs in June 2000
- Since then, 16 packs have flown on Shuttle missions without a discrepancy
  - 4 packs with 3 flights completed
  - 8 packs with 2 flights completed
  - 4 packs with 1 flight completed
- Total of 32 flight cycles of 1997 lot units without an inadvertent firing
- Therefore, all of these units have been exposed to the static buildup level associated with flight (movement, vibration, etc) without issue
- 1997 units designated for STS-104 have all flown on previous missions

FLU-8

- All flight units are from a 1996 lot (recently refurbished in 2000 & 2001)
- 7 of the 10 units designated for STS-104 have flown on a previous mission
- Previously flown units are available to replace the other 3 units if desired

	Presenter:
	Organization/Date: Orbiter/06-28-01

FLIGHT READINESS STATEMENT

SPACE SHUTTLE VEHICLE ENGINEERING OFFICE

STS-104 (OV-104) ☐ **ORR** ☒ **FRR** ☐ **Prelaunch MMT**

Pending completion of scheduled open work, the Orbiter vehicle, support hardware, flight crew equipment, and software are certified and ready to support. For United Space Alliance accountable functions, insight, audit, and surveillance activities have been reviewed, and there are no constraints to flight.

ORBITER / FLIGHT SOFTWARE / FLIGHT CREW EQUIPMENT

5-30-01
P. E. Shack, Manager, Shuttle Engineering Office

5/25/01
D. S. Rasco, Manager, Flight Crew Equipment Management Office

5/31/01
D. E. Stamper, TMR, Software

J. P. Mulholland, TMR, Orbiter and Flight Crew Equipment

REMOTE MANIPULATOR SYSTEM

S. Higson, Program Director, SRMS
McDonald Dettwiler and
Advanced Robotics Limited

R. Allison, RMS Project Manager

SPACE VISION SYSTEM

L. Beach, Program Manager, SVS
NEPTEC

D.S. Moyer, SVS Integration Office

FERRY FLIGHT PLANNING

D. L. McCormack, Ferry Flight Manager

Ralph R. Roe, Manager
Space Shuttle Vehicle Engineering

USA SSVEO Functions

STS-104 (OV-104) FLIGHT READINESS STATEMENT

☐ ORR ☒ FRR ☐ Prelaunch MMT

PENDING COMPLETION OF SCHEDULED OPEN WORK, THE ORBITER VEHICLE, SUPPORT HARDWARE, FLIGHT CREW EQUIPMENT, AND SOFTWARE ARE CERTIFIED AND READY TO SUPPORT.

ORBITER / FLIGHT SOFTWARE

Greg A. Ray

G. A. Ray, Program Director, Orbiter
Human Space Flight and Exploration
The Boeing Company

F C Littleton 5/29/01

F. C. Littleton, Associate Program Manager
Orbiter Element
United Space Alliance

T F Peterson 5/29/2001

T. F. Peterson, Associate Program Manager
Flight Software Element
United Space Alliance

FLIGHT CREW EQUIPMENT

for William Young 5/25/01

E. L. Young, FCE/EVA Associate Program Manager
United Space Alliance